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Fanny Brett
with her Grandmama's
best love. 26th May 185

MIDNIGHT.

MORNING.


EVENING.

NOON.

The figures denote Greenwich time when the line marked Meridian of Greenwich is brought opposite to them.

Direction in which the Sun shines, or

SUN.

12 o'clock line.

THE

# SCIENTIFIC PHENOMENA

OF

# DOMESTIC LIFE.

FAMILIARLY EXPLAINED

BY

CHARLES FOOTE GOWER, Esq.

SECOND EDITION.

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# THE SCIENTIFIC PHENOMENA

OF

# DOMESTIC LIFE.

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## INTRODUCTORY CHAPTER.

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"Nature and Nature's laws lay hid in night.
God said, Let Newton be, and all was light."—POPE.

"If casual concourse did the world compose,
And things and hits fortuitous arose;
Then anything might come from anything;
For how from chance can constant order spring?"—BLACKMORE.

IN these days of education and of the march of intellect, we commonly teach our children every art, every science, and every accomplishment that the mind of man can suggest; but it is too often that we forget to teach them that which would turn all these to good effect We forget to teach them to

think, to reason, to observe. It is for this purpose that this little book has been written; it is to illustrate the great book of Nature; for in it the child who has been taught to reflect will be furnished with an inexhaustible fund of amusement and instruction; and what to others is a blank, to such a youth will be replete with food for thought. And, moreover, every fresh scientific fact attained, will lead us, as a necessary consequence, to farther discoveries, all united together, and each step to information will tend to facilitate the next, and thus render its attainment more satisfactory, as a link in the great chain of the glorious works of their Divine Author.

"A mind which has once imbibed a taste for scientific inquiry," says Sir John Herschel, "and has learnt the habit of applying its principles readily to the cases which occur, has within itself an inexhaustible source of pure and exciting contemplations: one would think that Shakspeare had such a mind in view, when he describes a contemplative man as finding

> 'Tongues in trees—books in the running brooks,
> Sermons in stones—and good in every thing.'

Accustomed to trace the operations of general causes, and the exemplification of general laws, in circumstances where the uninformed and uninquiring eye perceives neither novelty nor beauty, he walks in the midst of wonders; every object which falls in his

way elucidates some principle, affords some instruction, and impresses him with a sense of harmony and order. Nor is it a mere passive pleasure which is thus communicated. A thousand subjects of inquiry are continually arising in his mind, which keep his faculties in constant exercise and his thoughts perpetually on the wing, so that lassitude is excluded from his life, and that craving after artificial excitement and dissipation of mind, which leads so many into frivolous, unworthy, and destructive pursuits, is altogether eradicated from his bosom."

The mind thus accustomed to search into the causes of different effects will not ascribe every strange or curious occurrence to the agency of chance or accident; for though to the unthinking and indolent this may appear to be a very satisfactory explanation, the mind desirous of knowledge will not rest satisfied with such meagre food, but rather will be well assured, that where there is an effect produced there must also ever be a producing cause.

> "All nature is but art unknown to thee;
> All chance, direction that thou canst not see."

In those circumstances, where chance* cannot readily be charged with any particular or mysterious

* Whilst on the subject of chance, it may be worthy of remark that even games of hazard can hardly, strictly speaking, be termed so. Let us take, for instance, the act of tossing up a shilling to see on which side it will fall. In this case, if we were aware of the exact weight of the coin, and the force employed to project it into the air, with the rotary motion communicated to it, we should be able to calculate the height it

effect, superstition, the hand-maiden of ignorance, steps in to assist, and many an awful tale has terrified the fire-side circle, which, if properly inquired into, would perhaps have been easily explained, and have carried with it instruction instead of terror. The celebrated spectre of the Hartz Mountains, in Germany, which, for ages, has at intervals appeared in the form of a gigantic figure in the heavens, has been ascertained to be nothing more than the shadow of a person projected on a back-ground of clouds. The writer well remembers a circumstance of this kind, which happened to himself and a friend on the summit of Snowdon, when they beheld their own shadows thrown upon a back-ground of clouds; and as the wind swept the clouds past, they appeared to approach or recede, and assumed at times a very grotesque appearance, from the variety of surfaces on which the shadows fell; at the same time they were surrounded by a circle of prismatic colours, forming a complete rainbow, though the colours were

would attain, and how many revolutions it would take before reaching the ground, consequently which side would be upwards; but as we have no means of arriving at this knowledge, it is uncertain to us which side will fall upwards, but the laws of matter had decided the question the moment the shilling was projected into the air; therefore it was not chance, but our undertaking to decide a question without any data from which to draw our conclusions. If a spring could be so placed as to throw the shilling with exactly the same force and direction, it would always fall alike. This will assist us to remember the two following axioms:—First, that no effect is produced without a cause; and, second, that similar causes will ever produce similar effects.

very faint. It required some experiments, such as taking off their hats, bowing, &c., before they could perfectly establish the identity of the shadows; and had they been at all inclined to the marvellous, might very easily have departed with the idea that they had seen an apparition. Perhaps it may be the curious effects of sight and sound produced by mountain scenery, that generally renders the inhabitants of those countries more prone to superstition than the inhabitants of less romantic regions. Dr. Arnott, in his excellent work on Physics, states that "it happened once on board a ship sailing along the coast of Brazil, one hundred miles from land, that the persons walking on deck, when passing a particular spot, heard most distinctly the sound of bells varying as in human rejoicings. All on board listened and were convinced, but the phenomenon was mysterious and inexplicable. The different ideas which this would excite in the minds of an intelligent or of an ignorant man may be easily conceived. Some months afterwards, it was ascertained that at the time of observation the bells of St. Salvador, on the Brazilian coast, had been ringing on the occasion of a festival. The sound, therefore, favoured by a gentle wind, had travelled over one hundred miles of smooth water, and striking the wide-spread sails of a ship, rendered concave by a gentle breeze, had been brought to a focus and rendered perceptible."

There are many every-day occurrences which puzzle us in the same manner, but which, on careful inquiry, can generally be detected: a cat finds access to an empty house, and the house gets the credit of being haunted; or a piece of broken looking-glass catches the reflexion from some distant lamp, and throws it on the window, and the report presently spreads that lights were seen in the house, when perhaps it was quite clear that no human being could be in the house at the time. These and hundreds of similar occurrences were the fruitful sources of the nursery tales of a former generation, now, however, fast fading into oblivion before the approach of education and inquiry. It has been well remarked, that "error always lies on the surface and is gathered by the superficial observer, whilst truth must be sought in deeper regions."

Let us not for a moment, however, confound the laws of matter with the agency of that Power, without whom not a sparrow falls to the ground. It is true that the hand of Providence can alter or annul the laws of matter, if He sees fit so to do: but it then becomes a miracle, and, as such, is beyond the finite powers of man to explain. The laws of which we treat, are those fixed rules which regulate created matter, and which we may depend upon with the same degree of certainty with which we expect day to be succeeded by night, or summer by winter

Having thus briefly explained to my readers the theory, that there is nothing, however simple, or however complex, but what is regulated by fixed and immutable laws, whether it be the falling of a leaf or the revolution of the universe, we will proceed to explain some of the phenomena which occur in our daily career.

# CHAPTER II.

## THE BED-ROOM.

"There is nothing too little for so little a creature as man. It is by studying little things that we attain the great art of having as little misery and as much happiness as possible."—Dr. Johnson.

"Happy the man, who, studying nature's laws,
Through known effects can trace the secret cause."—Dryden.

This treatise being intended more especially for the perusal of the young, the author will not apologize, for sometimes descending to what might otherwise be deemed examples too familiar to require explanation. He will, therefore, imagine himself to be the companion of his young reader, from his first awaking in the morning till the evening calls him again to repose; he will endeavour to explain to him the causes of the various phenomena that will fall under his notice, and send him to rest at night, gratified at finding so many wonders to admire and speculate upon, even in the daily routine of life, that formerly passed unobserved, because his attention had not been drawn to them.

We will, therefore, commence with the first object that presents itself to our view on our awaking on a

fine frosty morning. The window of our bed-room is probably covered with hoar-frost, whilst that of our dressing-room, though the aspect is quite as cold, remains perfectly clear. Now, what is the cause of this phenomenon? I imagine my young reader to ask me; why is it that our bed-room window presents so fanciful a picture of trees, leaves, &c., while the window of the dressing-room bears no such appearance?

In the bed-room, the vapour arising from the breath of its inhabitant, has created a damp atmosphere, which, floating about the room, when it arrives at the window becomes condensed upon the cold glass, in the same manner that a cold spoon condenses the steam which comes from the spout of a tea-kettle, or, as we may have frequently observed on cold-water jugs, or other glasses, when brought into a warm room. This condensed vapour would have run down the window in the form of water, as it frequently does, but from the severity of the external atmosphere, which has formed it into ice, in the most minute particles, and has caused those brilliant coruscations in every variety of form and shape, which the process of crystallization has produced, till the warm rays of the sun, as they gradually melt the frozen screen, will resolve it into its liquid state. The dressing-room having been destitute of an inhabitant, has had

nothing to produce a damp atmosphere, and therefore, though the temperature was the same, there is no appearance of frost on the window.

Another curious circumstance may arrest the attention of my young companion, on his rising from his bed, and that is, the difference he finds on putting his feet upon the carpet, or on the marble hearth, the cold of the first being scarcely perceptible, whilst the latter has a more chilly effect, and yet, if both were examined by the thermometer, they would be found of the same temperature, which we will suppose to be considerably colder than the foot.

To explain this, it will be necessary to remember the fact, that bodies of different temperature, when brought into contact, assimilate to the same heat; the one becoming colder as the other becomes warmer, till they are both of the same temperature. Some substances are much quicker at imbibing and imparting warmth than others, and are, therefore, termed good or bad conductors of heat. In the instance just mentioned, the carpet is a bad conductor; consequently, when the warm foot is placed upon it, the carpet not conveying the warmth from the foot, it does not suffer much loss of heat. With the marble hearth the case is different: marble is a very good conductor; the moment, therefore, the foot is placed upon it, the marble

absorbs a portion of the warmth, and having an easy mode of disposing of it, immediately calls upon the foot for a fresh supply. Had the substances been both of the same heat with the foot, they would each have felt equally warm, because their different conducting capacities would not then have been brought into action; but had they both been warmer than the foot, the marble would in this instance feel the warmest, and the carpet the coldest. In the same way we account for the cold felt on immersing the hand in a basin of water, though the water is probably warmer than the air, but the superior conducting power of water renders us far more susceptible to the cold when conveyed to us by water than by air; and as we proceed, we shall find many other facts, which can be explained in the same way.*

I will next draw the reader's attention to the pernicious practice of sleeping with the curtains

* That colour also exercises considerable influence in the absorption of caloric may be easily shewn by the following simple experiment. When the ground is covered with snow, take four pieces of woollen cloth, black, blue, brown, and white, and lay them on the snow exposed to the sun; in a few hours the black cloth will have sunk considerably below the surface, the blue nearly as much, the brown considerably less, whilst the white will remain precisely in its former position on the surface of the snow. It thus appears that the sun's rays are absorbed by the dark-coloured cloth, and excite such a degree of heat as to melt the snow beneath, but that they have little power to penetrate the white cloth. It is from this cause we observe that a white surface, such as the tombstones in a churchyard, will remain covered with hoar frost long after it has melted from the darker coloured foot-paths.

drawn close around our beds, which would scarcely be persisted in, did we but reflect on the effect produced by thus depriving ourselves of pure air during the hours of sleep. Air that has been once breathed is rendered unfit for animal life, until it has been again purified; it is composed of two gases, termed oxygen and nitrogen; the first of these is the great agent in respiration and combustion, and is often called vital air; the latter is of a contrary nature, and is fatal to animal life, and is also incapable of supporting combustion: it is hence often designated deadly air. Yet, on the proper mixture of these two gases, the purity of our atmosphere depends.

In the process of respiration, the air is deprived of a large portion of its oxygen, and obtains in its stead a portion of carbonic acid gas, which also, like nitrogen, is not capable of supporting life. It therefore follows that air, after having served the purposes of respiration, is no longer fit for man till it has been purified in Nature's vast laboratory, where that portion which was unfit for animal life is absorbed by the vegetable world, and the other substances with which it is brought into contact, and from them it again absorbs its proper proportion of oxygen gas.*

* Dr. Priestly has given us a beautiful exemplification of the powers of vegetables to restore the purity of air which had been deprived of its

The air, as it passes through the lungs, is brought into very close contact with the blood, as it returns from its circuit round the system; it is then in a dark discoloured state and unfit to be again circulated: in the lungs, however, it is brought into very close connexion with the atmospheric air, from which it speedily obtains a large supply of oxygen, which turns it to a beautiful bright red, and it is again fit to be expelled by the action of the heart to the extremities; the blood by this means

oxygen: he says, "finding that air was not spoiled by the growth of a plant of mint which I kept in it for some months, I thought it possible that the process of vegetation might restore the air injured by burning candles, and accordingly, on the 17th of August, 1777, I put a sprig of mint into air in which a wax candle had burned out, and on the 27th of the same month, I found that another candle burned perfectly well in the same air which had extinguished it before. This restoration of air," he says, "I found depended upon the vegetating state of the plant, for though I kept a great number of the fresh leaves of mint, and changed them frequently for a long space of time, I could perceive no amelioration in the state of the air: nor did this remarkable effect depend upon any thing peculiar to mint, for I found a quantity of this air to be perfectly restored by plants of balm, groundsel, spinach, and some others, which were used with like effect, to prove that it did not depend upon any aromatic effluvia from the mint." The same facts were found to result when the air had been deteriorated by animal respiration and putrefaction, and, "these proofs of a partial restoration of air, by plants in a state of vegetation, though in a confined and unnatural situation, cannot but render it highly probable that the injury which is continually done to the atmosphere by the respiration of such a number of animals, and the putrefaction of such masses of both vegetable and animal matter, is, in part at least, repaired by the vegetable creation; and, notwithstanding the prodigious mass of air that is corrupted daily by the above-mentioned causes, yet, if we consider the immense profusion of vegetables upon the face of the earth, growing in places suited to their nature, and, consequently, at full liberty to exert all their powers, both inhaling and exhaling, it can hardly be thought but that it may be a sufficient counterbalance to it, and that the remedy is adequate to the evil."

has become pure, but the breath at the same time has also become vitiated, being deprived of its vital quality, and having imbibed other impurities, chiefly carbonic acid gas, in its stead; it is therefore expired, and fresh air inhaled in its place. It therefore follows that the more we are exposed to the free air of heaven, the better will be the state of our blood; whereas, deprived of our full supply of this invigorating fluid, the animal frame becomes pale and emaciated; and we have only to compare the healthy ploughman, and the ruddy and hearty foxhunter, with the pale and sickly inhabitant of an over-populated manufacturing district, or the votary of fashion, the victim of the close and unwholesome air of a London fashionable life, to be quite aware of the benefit arising from a free circulation of pure air. Of this pure air a man requires about a gallon per minute. Now, the space within the curtains of a bed is not capable of containing more than sufficient for two persons for twelve hours, so that if the curtains were quite air-tight we should cease to exist: we may therefore easily imagine how prejudicial such an atmosphere must be. Beds made without any covering above occasion a much freer circulation of air, and are therefore more conducive to health. Nothing can be more ridiculous than the absurd plan of elevating the bed to a great height from the floor, and at the same time bringing the valance down to a

considerable depth from the top, thus shutting in a quantity of vitiated air just above. It is somewhere related that a bird, hung up in a cage within the curtains of a bed where a person is sleeping, will be found dead in the morning.

It may, however, be objected to such a proposed arrangement, that it is necessary to have hangings to our beds to protect us from cold. But where the constitution is delicate, and, consequently, requires a warm atmosphere, it would be far preferable to have the room warmed by some other means than to live in an impure air, merely for the purpose of increasing the temperature. It is not warm air that we are speaking against, but that which is vitiated, and, therefore, unwholesome.

I remember hearing a medical friend observe, that he felt less risk of infection in attending the fever wards of a hospital, where the beds are without testers or drapery of any kind, than in the more luxurious bed-rooms of the middle and higher classes of society, where, frequently, the excess of anxiety and fear, lest a too cold air should visit the patient, induces the tender nurse to draw the curtains close, and thus exclude the first of medicines—a pure atmosphere.

Whilst on the subject of respiration let us turn to the cause of vital heat, or the means employed by nature to keep our bodies so much above the temperature of surrounding objects; and we shall pre-

sently find that the heat of our bodies is kept up by a constant species of combustion, not differing essentially in theory from the combustion of fuel in a stove. The mixture of oxygen, which we have before stated to be the great supporter of combustion, with carbon, is always attended by the developement of heat. When oxygen in its pure state is brought into contact with carbon, the combustion is very intense and rapid; but when these substances meet together in a less pure form, the mixture, although producing the same amount of heat, with regard to the quantity of the pure elements brought into contact, is much less rapid. Thus, in the human body, the carbonic acid, which is produced from the carbon which we have consumed in the shape of food, mixing in the lungs with the oxygen contained in the atmospheric air imbibed in the act of respiration, combine to produce the heat which diffuses itself over our bodies.

It is a curious fact that, whether at the frigid regions of the poles or the burning climate of the equator, the human body is almost invariably of the same temperature, viz. about 99½ degrees; and whilst life exists this temperature remains undiminished. Hence it follows, that the body must need a much greater supply of fuel to keep up the heat lost in a cold climate than in a hot one; exactly as we should require to put more

coals on the fire to keep our room at the same temperature in those different situations. And we find that the inhabitants of the polar regions require a much larger quantity of food than the languid resident of a tropical climate; and Nature, ever careful to provide for the wants of her creatures, has wisely given to the inhabitants of Lapland, and those hyperborean regions, food which contains carbon and hydrogen, both highly combustible substances, in large proportions. Train-oil and whale-blubber contain near 70 per cent of carbon, whilst the food provided for the inhabitants of hot climates does not, perhaps, possess more than 12 per cent of this ingredient. Exposure to cold, therefore, is generally productive of hunger, because the loss of animal heat must be supplied, more oxygen is inhaled, and, consequently, more carbon is consumed, for the carbon consumed is ever in exact proportion to the oxygen inhaled; and with the consumption of carbon comes the desire to replace it, which makes itself known to us by the sensation of hunger.

Exercise, again, produces the same effect, by causing an increased respiration; an increased respiration causes a larger supply of the all-consuming power, oxygen, and the fuel is soon consumed in supplying the demands made upon it; the increased combustion shewing itself by the increase of bodily heat, resembling a fire which burns quietly till the bellows are

applied, when the greater supply of oxygen rapidly increases the combustion, and the fuel is speedily consumed.

Hence arises the objection generally felt by the poorer classes of society to a free circulation of air. With the rich and affluent, who have the means always at command to prevent the evils of cold by artificial warmth, by clothing, and by food, ventilation is a delightful luxury; but as Dr. Reid remarks, "Ventilation need not be expected where food, clothing, and fuel, are deficient. Heat is still more essential to the human frame than fresh air, which consumes the body by slow combustion or oxygenation, when food is not supplied. Defective ventilation reduces the oxygenation, preserves warmth, stupefies the feelings, and allays the pangs of hunger." And none are so sensible to the effects of cold air as those whom poverty has reduced to want and starvation. We therefore need not wonder that the habitations of the poor should be so wretchedly ventilated: it is with them a choice of evils; and they prefer the one with the least present misery, though productive of perhaps greater future evil, to the constitution both of body and mind. With the want of circulation inherent on a deficient supply of oxygen, comes the desire for artificial stimulants; and the gin-shop becomes the haven to which misery turns for the momentary oblivion of its woes.

There is open a vast field for useful benevolence in improving the dwellings of the poor, and little doubt exists that if comfortable habitations were provided, and warmed and ventilated on an economical principle, which the combining several together would give great facilities for effecting, that such habitations would let for more than remunerating prices; for it is a startling fact that the miserably poor inhabitants of Spitalfields and St. Giles's pay more for their house-room, considering the number of cubic feet of space they occupy, than does the aristocratic possessor of some of the mansions at the west end of the metropolis.

But to return to the phenomena of our bed-chamber, which our reader will think we have forgotten.

In performing our morning ablutions we shall probably be led to remark the difference between hard and soft water, as they are commonly termed, and the difference of their actions upon soap. Hard or spring water, though originally rain, has, by filtering through the earth for a considerable time, imbibed many impurities, by having come in contact with various earthy and mineral substances through which it has passed. These impurities, when using soap with hard water, have the effect of decomposing the soap, and preventing its solution with the water, on which the washing properties of the soap depend. Rain-water, before it has come in contact with any of these

soluble substances, is pure, being, as we shall shew in the next chapter, condensed steam; it therefore unites with soap, for it does not contain any chemical ingredient to decompose it.

Whilst speaking of the properties of hard and soft water in dissolving soap, we are forcibly reminded of our early days, and the many hours we have spent in blowing soap-bubbles, and watching the beautiful colours they assume, till, just as they appear to have attained the height of perfection, they suddenly vanish, and disappoint all our hopes, like many an airy day-dream, which, since that time, has filled our imagination and has as suddenly disappeared. If we attempt to blow bubbles in water, we fail in producing any of durability or size sufficient to admit of observation; but by the addition of soap we give a degree of tenacity to the liquid which allows it to form very thin films, for a bubble is nothing more than a very thin film distended with air. When blown by children from a tobacco pipe we sometimes see them ascend, the warm breath with which they are filled being lighter than the colder external air, the difference in the weight of the air being more than the weight of the light film forming the bubble; in a very few seconds, however, if they do not previously burst, these miniature balloons fall, the air contained in them condensing as they cool, when the weight of the film brings them to the ground. This, however,

is but a small portion of the wonders of the soap-bubble, which will, perhaps, be heightened in our estimation when we find that, by his observations upon it, the great Newton was assisted in some of the most astonishing discoveries in optics that have ever been made, and all this from a habit of examining into every effect that he saw produced. The changing colours of the soap-bubble caught his attention, but how to account for it was the difficulty which he has beautifully solved in his theory of light. It is, however, far too deep a subject for a work so limited in its size as this; I will therefore merely explain that white light, as we may term it, consists of three primary colours, red, blue, and yellow, but which, all blended together, produce white.* Now light, on passing through a medium such as glass or water, under certain circumstances becomes refracted or bent, as we shall see on proceeding farther; and according to the different degrees to which the ray is bent, it assumes different colours, on emerging by reflexion from the medium through which it has passed The various colours of the soap-bubble, therefore, depend on the thickness of the film through

* That the mixture of red, blue, and yellow, produce white may easily be shewn, by dividing a circular card into three equal parts, coming to a point in the centre, and painting one part blue, the next red, and the next yellow; if a pin be put through the centre, and the card be rapidly turned round on it, it will appear white.

which the ray passes, because different thicknesses will give a different angle of refraction or bending; and as a bubble is constantly growing thinner till it bursts, the various hues it presents are accounted for. The reason for its growing thinner is this, when the bubble is first formed it is perhaps equal in thickness in every part, but its shape causes it to drain; the water drawing down the sides of the film from the top, till the upper part becomes so thin as at last not to be able to support itself; the variation and constant change of thickness causing the various changes of colour.

# CHAPTER III.

## THE BREAKFAST-PARLOUR.

> "Soon shall thy arm, unconquered steam, afar
> Drag the slow barge or drive the rapid car
> Or on wide waving wings expanded bear
> The flying chariot through the fields of air."—DARWIN.

THE prophetic fancy of the poet—for it must be remembered that the above lines were written many years ago—has certainly, as far as concerns the early part of the prediction, been fully verified; how far the latter part may ever be fulfilled we must leave to futurity to decide. At present it certainly appears chimerical; but those who have observed the almost incredible strides which have within the last few years been made in every science, will be careful how they express too confident an opinion upon any subject not beyond the bounds of possibility.

Having entered the breakfast-parlour, let us then examine the phenomena which present themselves the most worthy of observation. The first striking object will be the kettle boiling on the fire, and steam

issuing from the spout. Here we have a familiar illustration of the process of evaporation, which, when carried on by Nature in her vast laboratory, is the cause of rain and fair weather, the sunshine and the storm; and if these causes were but for a short time suspended, the earth would become a barren wilderness, and man and all created things would soon be blotted from the book of life.

In the instance before us the fire is acting the part of the sun; and, on the same principle that we mentioned in the last chapter, when two bodies of different temperatures come in contact, the one imparts and the other imbibes. The fire imparts a portion of its heat to the water, which presently rises in temperature till it arrives at the boiling point, when it changes its character, and, from an almost incompressible fluid, becomes that highly elastic vapour steam, whose giant arm is so wonderfully employed in changing the face of the universe, and connecting the remotest corners of the globe by its expansive powers, or, in other words,—

> "To give the pole the produce of the sun,
> And knit the unsocial climates into one."

But perhaps it will be requisite before proceeding farther to say a few words on heat, or, as it is more scientifically termed, caloric. Caloric, then, may be familiarly defined as an extremely subtle quality re-

siding in every substance; and, although it cannot be termed material, it has the property of insinuating itself between the pores of substances, and causing them to repel one another and fly asunder—increase of temperature being almost invariably attended with increase of bulk. In the instance of the kettle, the water has absorbed a portion of caloric from the fire, which, mingling with its particles, has caused them to repel one another, till they have overcome the density of the fluid, and it flies off in the shape of steam. This vapour diffuses itself over the room till it meets with some cold surface, which condenses it into its original state of water.

If we hold a cold tumbler near the spout of a boiling kettle so as to receive the steam, we shall immediately perceive it condensing in small drops on the sides of the tumbler, and running down in a miniature shower; and in a room where there is a large party, and, consequently, a considerable quantity of vapour, though from the warmth of the room it may be invisible, we shall observe, on cold glasses being introduced, that they are immediately covered with steam, in a similar manner to the tumbler we have just held near the spout of the kettle.

It is from a circumstance exactly resembling this that southerly winds are often accompanied with rain. The regions over which a southerly wind has passed in coming to us are generally warmer than the part

we inhabit; the wind, therefore, is warmer. Now we have shewn that warm air will retain a larger portion of vapour than cold air will, because, when the cold tumbler was brought into the room, the water contained in solution in the air was immediately deposited on the glass. In the same way the warm south wind, when it arrives in our colder climate, which may be likened to the cold tumbler, is obliged to abandon a portion of the vapour it held in solution, which consequently falls in the shape of rain. It at first appears extraordinary that steam, which is, as we have just seen, only water in a different form, should be so light as to rise in air—that almost imperceptible fluid—yet such is the case; the repulsive power of heat having separated its particles to such an extent that it has become even lighter than air, that is to say, a pound of water converted into steam occupies more space than a pound of air would do. It is, therefore, specifically lighter, and floats in the air till the coldness of the atmosphere into which it ascends, by robbing it of its caloric, reduces it to a denser fluid, when it descends in an almost imperceptible dew or rain.

Our observations from the steam issuing from the spout of the tea-kettle have thus led us to understand some part of the theory of the atmosphere by which we are surrounded. We will now take a glimpse at the use to which the ingenious mind of man has

turned this wonderful power, steam. And it is worthy of remark that to a boiling kettle we are said to be indebted for the first practical hint of the application of steam to any useful purpose.

It is related of the Marquis of Worcester that, during his confinement in the Tower about the year 1660, whilst engaged one day in boiling some water in a vessel over the fire in his apartment, the cover being closely fitted on, was, by the expansion of the steam, suddenly forced off and driven up the chimney. This circumstance attracting his attention, led him to a train of thought which terminated in this important discovery. But no figure has been preserved of his invention, nor any description of the machine he employed, except from an article in his work entitled "A Century of Inventions." This article we extract from a manuscript of the noble author preserved in the British Museum :—

"An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be, as the philosophers call it, 'infra sphœrum activitatis,' which is but at such a distance. But this way hath no boundary, if the vessel be strong enough, for I have taken a piece of a whole cannon, whereof the end has burst, and filled it three quarters full of water, and screwing up the broken end, as also the touchhole, and making a constant fire under it, within twenty-four hours it burst

and made a general crack. So that having found a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain stream forty feet high; one vessel of water, rarified by fire, driveth up forty of cold water. And a man that tends the work has but to turn two cocks, that one vessel of water being consumed, another begins to force and refill with cold water, and so successively the fire being tended and kept constant, which the self-same person may likewise abundantly perform, in the interim between the necessity of turning the said cocks."

It appears from the above extract that the Marquis was quite acquainted with the expansive power of steam; for before his time, though there had been attempts at steam as a moving power even as far back as the time of Hero of Alexandria, two thousand years ago, still they all seem to have consisted in nothing more than allowing the steam to escape from a jet or orifice in a bent pipe or hollow wheel, the steam issuing with considerable force, and pressing against the surrounding air, thereby causing the wheel to revolve in an opposite direction. But a very slight examination will shew that these ideas were far from being of use for any practical purpose. The Marquis, therefore, we think, merits the honour of being the first who brought his invention into any

useful form; and, shortly after, we find Captain Savery obtaining a patent for a new mode of raising water and communicating movement to a variety of machines by the force of steam. The apparatus invented by him was usefully employed for forcing water out of mines.

His invention consisted in a boiler for the produc tion of steam, which then issued into a large iron ball or receiver, which receiver was connected by a pipe with the water in the well beneath. The receiver being filled with steam, and the air allowed to escape from it, was then suddenly cooled by allowing a jet of cold water to flow over it; this condensed the steam within into water, and caused a vacuum in the receiver. The weight of the atmosphere, therefore, acting on the water in the well, forced it up the pipe to supply the empty space caused by the condensation of the steam, and a valve being placed at the top of the pipe as soon as the receptacle was filled, closed and retained it there. The water was by this means lifted part of the way out of the mine; but as the weight of the atmosphere was only sufficient to raise it to a height not exceeding thirty feet, a second operation was necessary to raise the water to the surface of the earth, if the mine was beyond that depth. For this purpose, as soon as the reservoir was filled with water the steam was again turned into it, which, pressing on the sur-

face of the water, forced it up a rising pipe, which issued from the bottom of the reservoir. As soon as all the water was forced out by the reservoir becoming full of steam, the condensing process was again resorted to. Two reservoirs were afterwards employed, which rendered the discharge of water more constant.

This machine, however, though so simple and inexpensive, was a very wasteful way of employing steam, as allowing it to come in contact with the surface of the water, condensed a vast body of steam before it acquired sufficient power to drive the water out. When the evils attendant on any particular system are fully understood, the remedy is seldom far distant; and we consequently find the next improvement to be one by which the steam was allowed to pass into a cylinder having a piston fitted so as to move up and down in it. Steam, being then admitted beneath the piston, forced it to ascend, filling the cylinder with steam; a jet of cold water being then introduced into the cylinder, condensed the steam, forming a vacuum, and the piston was forced down by the pressure of the atmosphere. A constant movement being thus produced, was easily applied by means of wheels and levers to any purpose that might be required.

Continued improvements have been from time to time made in the steam-engine, and every day is still

adding to their number. Where so much reflection is brought to bear on any subject, it is impossible to say what new resources may be discovered. The perfection of to-day becomes superseded to-morrow, and even the giant steam itself may succumb to a mightier agent — the at present almost unknown power of galvanism may prove no contemptible rival.

The current of air and smoke which ascends the chimney is again an object to attract our attention — caused by the same expansive power of heat. The air as it passes through and over the fire becomes greatly increased in bulk, and consequently lighter; that is, a gallon of air expanded to double its bulk, or two gallons, will weigh only as much as it did before it was so increased, which causes it to ascend through the denser part, leaving its space to be filled by cold air from the door or window. By this means the fire is supplied with the proportion of fresh air necessary for combustion, whilst a considerable quantity of rarified air ascends the chimney, carrying up with it the smoke or dense vapour which arises from burning bodies.

It may be inquired how it is that, when a fire is lighted in a room, the air does not descend the chimney to supply it, because that appears the easiest access to the outside air; and this, if the chimney were very large and quite open above, so as to admit

space enough for an ascending and descending current, might be the case. To obviate this, if the chimney is large, we contract the opening at top, by putting on a chimney-pot, by which means the current of ascending air is rendered so strong through the small aperture as to prevent the external air from entering. We are very frequently disturbed by smoke coming into our rooms, particularly at first lighting a fire, and more especially when other fires in the house have been burning some time previously. When this is the case it will occasion a downward current of air in the chimney, caused by the other fires requiring a supply of air, and the open chimney being the easiest way by which the air can find admittance, occasions the chimney to smoke when the fire is first lighted; but if the door of the room is closed and a slight portion of the window opened, the room is cut off from communication with the other fires, and the smoke will then ascend the chimney. When the fire is sufficiently established to cause a good draught, the window may be again closed, and the door opened without further annoyance, because the air to feed the other fires in the house will no longer find this chimney the easiest way of introduction, and some other means of entrance will probably soon discover itself.

Sudden gusts of wind are apt to cause chimneys to smoke, by removing the equality of the atmo-

spheric pressure on the outside, whilst the interior pressure is not exactly subject to the same influence. During the gust, the perpendicular pressure of the atmosphere above is partly removed by the velocity with which it passes over, in the same manner that the pressure or weight of a cannon-ball is removed from the earth while it is flying along, its velocity having overcome its gravity or weight; but when it loses its velocity its weight again becomes perceptible, and it falls to the ground. The consequence is that, during the time of the gust, whilst the pressure is removed, there is a rapid draught up the chimney, caused by the want of resistance above; but the moment the wind lulls again this pressure returns, the upward draught is suddenly checked, which causes a momentary obstacle to the ascending current, and a puff of smoke in the room is the most probable result. Some particular direction of wind will generally influence a chimney in this way more than another, either from some peculiarity in the situation of the chimney above, or from the apartment being more or less immediately influenced by the same cause; for, it is clear, if the variation of pressure above and in the room is simultaneous, no confusion will take place, but if the one happens a few seconds after the other a contrary effect will be produced.

In warm weather we often find a disagreeable

smell of soot in our rooms, the reason of which is, that in the day-time, whilst the outward air is very warm, the chimney not having been in use, and being shaded from the sun, is considerably colder than the air, it consequently cools the air and condenses it, causing it to descend into the room; in the night when the air in the room is warmer than the outside air, it expands and rises in the chimney.

It is this same principle which influences the land and sea-breezes of tropical climates; the surface of the land becoming very much heated by the perpendicular rays of the sun, the air above it is warmed, which causes it to ascend, and the space left is filled by fresh air from the sea; for the sun's rays having penetrated deeper into the water, the surface has not become so hot, and the air above is comparatively cool. In the night when the surface of the earth becomes cool, the air above it condenses and descends, whilst the air above the water has become the warmest, because the water is giving out the heat which it had imbibed during the day; the wind will, therefore, blow from the land to the sea. This effect is often observable, even in our own country, during a continuance of clear, sunshiny weather on the sea-coast, where the wind will be found to blow from the shore in the morning, and the sea-breeze will set in about the middle of the day. The invigorating effect of these sea-breezes can only be esti-

mated by those who have felt their delightful influence in a tropical climate. It is from the same cause that islands are more equal in their temperature than continents, the water surrounding them acting as an immense magazine to absorb the heat during the summer, and to render it back again during the winter months. It is a common remark that the climate of England is very variable, which is quite true as far as regards changes from wet to dry, and minor changes of temperature, but the variation between summer and winter is with us much less than the variation between these seasons in a similar latitude in Russia and America; for, although those are more settled climates than ours, their winters are many degrees colder, and their summers hotter.

We stated in the last chapter that air became vitiated by respiration, having, in its passage through the lungs, become considerably heated and expanded; as soon, therefore, as it issues from the mouth, it ascends, and carries its impurities with it far over head; where, being brought into contact with other substances, it in time becomes purified, and, as it cools and descends, is again rendered fit for the support of animal life. Let us consider the consequences that must result if air increased in weight by becoming warmer; every respiration we made, the vitiated air would descend, till in a short space of

time it would have accumulated so as to reach our mouths, and we should then be as effectually suffocated by the flood of noxious vapour as if we were to remain in the channel of the Thames till the water flowed over our heads. The shortest would, of course, be first overwhelmed, whilst a few of our long-legged neighbours might hold up their heads and contemplate the surrounding desolation. Indeed, there is not a single law of nature, the suspension of which would not in a very short time be followed by our destruction; and we may be assured, that the more we search into these laws, the more we shall be astonished with the simplicity and beauty of Nature's contrivances and their wonderful adaptation to the circumstances for which they are designed. Unlike the fallible mechanism of human construction, which the more we magnify the plainer the defects appear, in her works, though we should magnify them to fill the universe, still all would be perfection and all beauty. To convince ourselves of the truth of this assertion, let us, for instance, examine the point of a needle with a microscope, and it will appear a broad, rough surface; but let us also examine the sting of the bee, and it will still retain its delicacy of appearance; or let us take some of the extremely delicate parts of which a flower is composed, and we shall be still more struck with wonder and admiration.

We will now take a glance over the breakfast-table, and we shall be reminded that a bright, silver tea-pot will make better tea than an earthenware one, and for this simple reason that bright surfaces radiate, or throw off heat much slower than black and dull ones, consequently the tea is kept hotter. From this we may learn that, whenever heat is to be retained, a bright, polished vessel should be employed; but, on the contrary, if we want a vessel to absorb heat rapidly, a black, dull surface is the best. The quickest boiling saucepan, therefore, will be one which is black on that part exposed to the fire, but bright on the portion which comes only in contact with the air; the black part as a good conductor, to allow the heat to approach the water, the bright as a bad radiater to prevent its escape. Woollen, as we before stated, in the instance of the carpet, is a bad conductor, therefore a very proper substance to wrap round any thing which is to be kept hot; and, by the same reasoning, although it may sound rather contradictory, it will equally keep any substance cold; for instance, a piece of ice, wrapped in woollen, will be much slower in melting than another piece not so enveloped. Heat and cold, we must remember, are only relative terms, as there is no precise point where heat ends and cold begins.

Before we leave the breakfast-room, we will just observe the effect of a lump of sugar put into a cup

of tea. We shall find it will be some time melting, if left at the bottom of the cup, but if we hold it in a spoon at the surface of a cup, it will dissolve very speedily. This arises from the sugar, as it melts, rendering the tea heavier; the sweetened portion, therefore, descends, leaving the sugar constantly in contact with a fresh portion of unsweetened tea, keeping up a continual circulation till it is all dissolved: whereas, when the sugar is at the bottom of the cup, it remains in the sweet portion of the liquid, which, becoming saturated, ceases to dissolve the sugar, and it requires stirring to bring it in contact with the unsweetened portion of the tea.*

* This may be very prettily shewn if we colour a lump of sugar with a little ink and put it at the bottom of a deep glass and gently fill it with water; then colour another lump of sugar, and hold it at the surface of another similar glass: the one will be dissolved very quickly, while the other will remain at the bottom of the glass.

## CHAPTER IV

### THE MORNING WALK IN THE FIELDS.

> " Cool breathes the morning air, and
> Spreads wide her hoary mantle o'er us."—GRAY.

> " When first the sun too powerful beams displays,
> It draws up vapours which obscure its rays;
> But e'en those clouds at last adorn its way,
> Reflect new glories, and augment the day."—POPE.

A WALK in the fields, whether they be clad in the russet livery of winter or in the glowing tints of summer, is ever replete with subjects for meditation, and the observing mind will have proceeded but a very short distance before its attention will be arrested by some object worthy of investigation.

Perhaps the first inquiry may be directed to the cloud of steam, which, as soon as we leave the warm atmosphere of the house, has become visible issuing from our mouth and nostrils. Here we have an instance similar to that mentioned in the bed-room, where the moisture occasioned by our breath was invisible till condensed on the cold window; our

breath, whilst in the house, was not perceptible, the warmth being sufficient to keep it in a state of invisible vapour; but the cold of the outside air at once condenses it, and it becomes a cloud of steam, fringing our hair and the brim of our hat with bright drops of pearly dew;—that poor wagon-horse, who has been out since the early morning, is not only fringed with this dew, but it has actually frozen into icicles on his long, hairy coat, and we cannot but admire the beneficent hand of Providence, which has furnished him with so thick a coat for the winter, and will relieve him of it when the warm weather of summer would make it burdensome.

The hoar-frost that we see covering the trees arises from the same cause,—during the night a thick fog or vapour enveloped the earth, and towards morning a sharp frost, setting in, cooled every branch and spray, causing the vapour to condense and freeze upon them, forming those beautiful glittering particles which so brilliantly reflect the rays of the sun, as it emerges from the lower atmosphere of vapoury clouds; his warm and genial rays we shall soon find will disperse all these mists and exhalations, or, to speak more properly, will render them imperceptible to us, as the poet philosophically remarks,

"The mists flew upward and dissolved in day."

We shall presently find, as the atmosphere becomes

warmer, that the breath from our mouth and nostrils has again become invisible.

The earth, warmed by the heat of the sun, is constantly sending forth vast volumes of invisible steam or vapour (which may be proved by inverting a glass on the ground on a fine day, when, if the glass be kept cold the inside will soon be covered with steam), indeed the quantity is so great, that twenty-five hogsheads of water will be evaporated from the surface of a square acre in twelve hours. It is this vapour, when condensed by any sudden change in the temperature, that produces the fog, the cold of the atmosphere acting in the same manner as the tumbler in the experiment. It may also sometimes, on a very warm day, be observed producing a dazzling effect to the height of a few feet from the ground, much resembling the vapour arising from a brick-kiln. It does not, however, appear to us in its moist form, till the chill of the evening condenses it, and during the cold of the night it will descend in dew, and settle on every herb and plant, thus returning some of the moisture it has robbed them of during the day.

The very common but mistaken idea, that the fog which we see of an evening hanging over low meadows, and by the sides of streams, is *ascending*, arises very naturally from our first observing it in low places. The fact is, however, not that the damp

is ascending, but that, from the coldness of those situations, they are the first places which condense the before invisible vapour, and as the cold of the evening advances, this condensation takes place at a higher level. A large portion of the vapour ascends to the upper regions of the atmosphere, where it cools, and becomes visible to us in the form of clouds, and increasing in density by cooling, they gradually descend nearer to the earth, until at last becoming too condensed by the loss of heat, they fall in rain, to be again returned in endless succession.

Evaporation always produces cold, because the heat which is required to convert water into steam must be withdrawn from the surrounding medium; hence, wet summers are often succeeded by cold winters, the greater evaporation produced from the excessive moisture having reduced the temperature of the earth. That evaporation produces cold may be immediately proved by moistening the palm of the hand and exposing it to the wind, thus causing evaporation, when cold will be very sensibly felt, and the more so if we use a volatile fluid, such as sal volatile or spirit of wine, the greater rapidity with which they evaporate producing a greater degree of cold.

It is for this reason that remaining in wet clothes is so dangerous; the evaporation that takes place

during the time they are drying carries away so large a portion of heat from the body as almost certainly to induce cold and all the thousand diseases which follow in its train. When a person is obliged to remain in wet clothes, the best method to adopt is, to prevent evaporation by covering them with a macintosh, or any other garment which will best keep the moisture in; and if this is effectually done the person will feel little inconvenience from his damp clothes; the warmth of the body will soon communicate itself to the damp garments under the macintosh, and as the steam cannot escape through it, there is nothing to produce a greater degree of cold than if the garments had been dry. Let it not, however, be supposed, that I recommend keeping on wet clothes, I merely advise this proceeding in cases where it cannot be avoided.

We may often observe on a fine clear day, that the sky becomes suddenly overcast, and we wonder from whence the clouds have come. Now, this is most probably the effect of a sudden change of temperature, which has condensed and rendered visible, in the form of clouds, that vapour which was before floating unperceived in the atmosphere. Southerly winds commonly bring rain, because being warm and replete with aqueous vapours, they are cooled by coming into a colder climate, and, therefore they part with some of their vapour and suffer it to pre-

cipitate in rain; whereas northerly winds being cold and requiring additional heat by coming into a warmer climate, are ready to absorb and receive more vapour than they before contained, and, therefore, they are dry and parching, and commonly attended with fair weather.

Snow is nothing more than rain congealed in the high regions of the atmosphere before it has become dense enough to be formed into drops; and hail is rain, which, during its descent, and after having been formed into drops, passes through a stratum of very cold air which transforms the drops into ice. This cold stratum is often the result of the electric state of the atmosphere, and is frequently accompanied by storms of thunder.

The formation of ice, as it shoots its long, needle-like crystals from the margin of a shallow pool till it has covered the whole surface with a solid substance, is a very beautiful phenomenon, although rather a cold one to observe; and, as my young reader may not be quite so enthusiastic an admirer of nature as to relish being frozen in the inquiry into her laws, we will instruct him how to examine the formation of ice by the fire-side, which can be done by mixing a handful of salt in a dish of snow, which mixture produces an extreme cold. If a saucer, partly full of cold water, be placed in the dish containing the salt and snow, it will rapidly

congeal, even in a warm room, the only difference being that the crystals will shoot more from beneath than they would have done in a pond, from the freezing mixture being placed below the saucer.

I have before remarked, that heat generally expands bodies, and that cold contracts them; but in the case of freezing, Nature has deviated from her general rule, and a very important deviation it is, water, when frozen, taking up more room than before. This is caused by the arrangement of its crystals, which do not form a compact body, but leave small interstices between them, thus increasing its bulk, as will very easily be understood by those who have observed the foregoing experiment. This increase of bulk renders ice specifically lighter than water; it, therefore, floats on the surface. Had the contrary been the case, on their forming on the top of the water, it would have immediately sunk to the bottom, where, being out of the reach of the horizontal rays of a winter's sun, it would have continued accumulating by each succeeding frost, till the rivers would have become one mass of ice, and the torrents caused by the thawing snows and rains of spring would find no egress; the surrounding country would be inundated; the labours of the husbandman destroyed; in short, such a catalogue of evils would ensue as we can scarcely calculate upon.

Water, when cooled below 32 degrees of the

thermometer, loses its fluidity with its heat; and we may observe, that most bodies can exist, either in a solid or a fluid state, according to the quantity of caloric combined with them. Thus iron, lead, and other metals, become fluids when greatly heated: and water, quicksilver, and other liquids, lose their fluidity by the abstraction of heat. The terms fluid and solid, therefore, like heat and cold, are relative terms, according to the temperature at which we are accustomed to observe them; for if we lived in a temperature below 32 degrees, we should certainly class water as a solid, and could we exist with the thermometer above 212, we should only know water as steam; and, again, were our temperature increased to 600, at which point lead melts, we should then class lead as a fluid.

The expansion and contraction of water in the wonderful process of freezing and thawing tends to pulverise the soil, and to separate its parts from each other—to act as the most effectual plough that can be put into the ground, rendering the whole penetrable to the air, the dew, the warmth of the sun, and the other nutritive agencies of vegetation.

When ice is converted into water, in the process of thawing, a very curious phenomenon takes place, which is accounted for by the theory of latent heat, by which is meant a certain portion of caloric which has become *dormant*, if I may use the expression;

that is, it becomes insensible both to the touch and to the thermometer. This will account for the very common expression of a "cold thaw;" the ice, in becoming liquid, having abstracted a large portion of heat from the surrounding atmosphere. If we mix a pound of water at 32 degrees of the thermometer with a pound of water at 172, the mixture will assume a mean heat between the two, or 102 degrees; but if we mix a pound of water at 172 degrees with a pound of ice at 32, which you will observe is the same heat as the water in the first experiment, we shall find the ice thawed; but on immersing the thermometer into the mixture, it will stand exactly at 32 degrees instead of 102, as before. What, therefore, has become of the heat which has quitted the water? It has passed to the ice, but has become latent; that is, we cannot detect it, though we are quite aware of the loss of caloric that the hot water has sustained.

We have mentioned the effects of frost and the atmospheric agencies in breaking up the soil and rendering it fit for the purposes of agriculture. We will now give a few moments to the consideration of the nature of the soil and the phenomena displayed in the production of vegetable life.

The soil considered mechanically is merely that substance in which the plant projects its roots or anchors, by which it attaches itself to the locality

where the seed is deposited; but, even in its mechanical part, it is of much consequence that it should be adapted to its situation and to the species of vegetable production that is to be cultivated upon it. In some situations it will be beneficial to have a sandy soil to aid in disposing of a too abundant supply of moisture, whilst in another situation, such as a sloping hill, a sandy soil would be very disadvantageous, and one better adapted to retain moisture far preferable. An instance of a purely mechanical soil may be seen by sowing some seeds of mustard and cress in a piece of moist flannel, which, if kept warm, will be found to vegetate; the blanket, however, only acts the part of keeping the plant in its proper position and place, for its nutriment is derived from the air and water with which it is supplied. Most soils contain some portion of vegetable matter, on which their richness depends; but, by constantly cropping, this rich matter becomes exhausted, and, therefore, the best soils, without the addition of manure, will soon lose their productive qualities; those, however, of the best mechanical construction will be the most easily restored to a healthy state.

There are certain elements contained in every plant, without which it cannot exist: different plants contain different elements, and in different proportions. Many of these are derived from air and water,

which was the case in the mustard-seed, though it is doubtful whether this plant would produce seed without some further nourishment; air and water may suffice for the stalk and leaf, but still not be enough for the perfecting the plant.

Plants and flowers left to the guidance of nature soon establish themselves in those places best suited to their wants, whilst in situations not congenial to them, they soon wither and die. The wall-flower chooses for itself some old ruin, where it finds a plentiful supply of lime furnished by the old mortar. The common nettle contains saltpetre, and hence is always found around stables, out-buildings, and other localities where saltpetre is generated. The violet finds itself a shady bank; the forget-me-not and the iris, also, will be seen frequenting the brooks and streams, with many more, that each seeks its peculiar locality.

It may be inquired how it is that these indigenous plants grow year after year in the same place without exhausting the soil, whilst if the farmer grows the same crop for several successive years, it will be sure to fail. The difference is this, that in the one case the plants perish, but the elements remain to promote a fresh growth the following year, and those parts which have returned to air and water can be again supplied by those fluids; but the farmer's crop has been removed from the land to return no more,

and consequently the elements for that species of crop will soon be expended, if not renewed by manure, or some other matter containing them. The first is a natural, the second an artificial state.

Temperature also exerts a very considerable influence on the growth of plants, for it must be remembered that all plants absorb their nourishment in a fluid state, and consequently, on the summits of very lofty mountains, where the heat, even in summer, is not sufficient to melt the ice and snow, we find that vegetable life ceases, and it is curious to observe how, as we ascend higher and higher, the hardy fir-tree, the boldest pioneer in those dreary regions, becomes gradually more and more stunted in its growth, till at last even *it* ceases to exist, and one long dark level line of green marks the limit that Nature has set to the progress of vegetation, ushering in the regions of eternal snow and solitude.

"The influence of the change of seasons and of the position of the sun on the phenomena of vegetation, demonstrates the effects of heat on the functions of plants. The matter absorbed from the soil must be in a fluid state to pass into their roots, and when the surface is frozen they can derive no nourishment from it. The activity of chemical changes likewise is increased by a certain change of temperature, and even the rapidity of the ascent of fluids by

capillary attraction. The last fact is easily shewn by placing in each of two wine-glasses a similar hollow stalk of grass, so bent as to discharge any fluid in the glasses slowly by capillary attraction; if hot water be in one glass, and cold water in the other, the hot water will be discharged much more rapidly than the cold water.

"The fermentation and decomposition of animal and vegetable substances require a certain degree of heat, which is consequently necessary for the preparation of the food of plants; and as evaporation is more rapid in proportion as the temperature is higher, the superfluous parts of the sap are most readily carried off at the time its ascent is quickest."*

If we examine the vegetable productions of the earth under different circumstances, and in various climates, we shall find an instructive mass of facts with regard to the habits and food of vegetation, all, however, more or less connected with the temperature which the plant is calculated to endure, or which best suits its habits. Thus a high temperature seems to produce on plants an effect somewhat analogous to that of heat upon animals: they become less sensible of its action; are, in other words, influenced by it with increasing difficulty, and, therefore, lose their excitability, or power of

* Davy on Agricultural Chemistry.

being developed by it to the greatest extent. Thus, in Jamaica, and some of the mountainous islands of the West Indies, the air upon the mountains becomes soon after sunset chilled and condensed, and by its gravity descends, and replaces the warm air of the valleys where the sugar-canes grow; thus producing an inequality of temperature, which, so far from proving detrimental, is beneficial to the plants, and the sugars of Jamaica take a higher price in the market than those from the less elevated islands, where the temperature of the night and day are more equable. And, for the same reason, we find the progress of vegetation in our temperate climate to be slow and gradual, whereas in Russia, where the cold of winter is intense, we find the whole vegetable kingdom bursting at once into strong and vigorous life, and as the heat of their summer, like the cold of their winter, is extreme, the excitability of the plant is continued during the brief season of summer, making up in speedy developement what they lose in time; till over exhausted, the long cold winter is requisite to prepare them for the following season. The action of heat on plants seems, therefore, more to depend on the former habits and customs of the plant, than on its exact amount; thus a grape vine, which has during the winter been exposed to the external air, will, if taken into the hot-house, vegetate vigorously, whilst, at the same time, a similar

plant, which has remained housed all the winter, will hardly have made any progress.

It has been remarked, that the ill effects of keeping up a high temperature in hot-houses during the night, is, that it exhausts the excitability of the tree much more than it promotes its growth, or accelerates the maturity of the fruit, which is, in consequence of this management, ill supplied with nutriment at the period of its ripening, when most nutriment is probably wanted. The Muscat of Alexandria, and other late grapes, are often seen to wither upon the branch in a very imperfect state of maturity, and the want of richness and flavour in other forced fruits is often attributable to the same cause.

The study of the effects of temperature will be of considerable advantage to the cultivator in several ways. It will explain to him, amongst many other interesting facts, why it is that the improved drainage of a district increases its warmth; and why judiciously placed plantations of trees, as in belts and in hedgerows, retard the rapid evaporation produced by the wind, and consequently the frequent sudden production of cold so common to exposed countries. And again, the improvement of the soil by deeper ploughing, or more finely pulverising the soil, by admitting more freely the access of the atmospheric air, increases very sensibly its mean temperature;

dressing clay soils with sandy ashes, or other porous materials, produces the same effect. And hence, in the more northerly portion of our island, by such general improvements, a very sensible increase to the temperature of certain districts has been experienced. When France and Germany were covered with wood Europe was much colder than at present; the winters were longer; the vine could not be cultivated on this side of Grenoble; whilst the Seine froze every year.

The causes why forests thus lower the temperature are plain. They detain and condense the clouds as these pass; they pour into the atmosphere volumes of water dissolved in vapour. Winds do not penetrate into their recesses; the sun never warms the earth they shade; and the soil, being porous, as formed in part of the decayed leaves, branches, and stems of trees, and coated over besides by a thick bed of brushwood and moss, is constantly in a state of moisture. The hollows in them serve as reservoirs for cold and stagnant waters; their declivities give rise to numberless brooks and rivulets; the best-wooded countries being ever those which are watered by the largest rivers.

In proportion as man, who finds himself cramped in countries of long-standing civilisation, extends the boundaries of his domain by stripping the soil of its ancient forests, so the wind and sun disperse the

superabundant moisture; the springs exhaust themselves; the lakes dry up; inundations cease altogether, or confine themselves to a smaller extent; the volume of water carried along by rivers diminishes, and the atmosphere becomes warmer and drier. These are results that cannot be denied; and, without mentioning the numerous evidences which history offers, it will be sufficient to adduce the United States of America as a proof. It is a fact admitted by all, that the clearing of the woods, begun two centuries ago in the European countries, and continued unceasingly to this day, has occasioned a very evident diminution in the quantity of water, and a perceptible elevation in the temperature of the atmosphere. But where, from improvidence or brutal selfishness, man has destroyed the woods of a country without reserve, the soil, bereft of the moisture requisite to the maintenance of vegetation, has been reduced to the most fearful sterility. The Cape de Verd islands, once watered by numerous springs, and covered with lofty forests and luxuriant herbage, now present to our view only waterless gullies, rocks bared of their mould, with here and there a patch of parched herbs, some stunted bushes, and a few plants of the succulent kind, such as *Cacalias*, *Spurges*, &c.

Hence it appears that man has, to a certain extent, the power of altering the climate of the district

he inhabits, though the instance of the Cape de Verd islands just mentioned, shews it to be one that requires to be exercised with great caution, lest, in subverting the course of nature, to avoid an apparent evil, we should call down upon ourselves a greater calamity than the inconvenience we were anxious to avoid.

Another great and necessary agent in the perfecting of vegetable life is light; and we shall find its importance to be greater than we might at first sight have expected, though we are all aware of the sickly appearance that plants assume when deprived of its invigorating influence. That it exerts great power over the absorbent properties of the plant, and by this means increases the flow of sap, appears very probable; but that the light of the sun causes the decomposition of carbonic acid, fixing the carbon, and giving out the oxygen, and thus promoting the growth of the plant, and increasing its value as an article of food, is beyond a doubt.* Light is also

* "The fixing of carbon by the action of light contributes, in an eminent degree, to the quality of timber, a point of no small importance. It is in a great degree to the carbon incorporated with the tissue, either in its own proper form, or as resinous or astringent matter, that the different quality in the timber, in the same species of tree, is principally owing. Isolated oak-trees, fully exposed to the influence of light, become a tougher and a more durable timber than the same species growing in dense forests; in the former case its tissue is solidified by the greater quantity of carbon fixed in the system during its growth. Thus we have every reason to believe that the brittle wainscot oak of the Black Forest is

the cause of colour in plants, for we find that deprived of it they soon become white, and are also very materially altered in their flavour; as is the case with endive, which, when bleached by being excluded from light, loses its bitter taste, for plants grown in darkness contain no juices except those that are saccharine and watery.*

the very same species that produces the tough and solid naval timber of Great Britain. Starch, again, in which carbon forms so large a proportion, and which, in the potato, corn, and other plants, ministers so largely to the nutriment of man, depends for its abundance essentially on the presence of light. For this reason potatoes grown in darkness are watery in consequence of no starch being developed in them, and the quantity of nutrition, or amylaceous matter, they contain is in direct proportion to the quantity of light to which they are exposed. For this reason, when orchard ground is undercropped with potatoes the quality of their tubers is never good, because the quantity of light intercepted by the leaves and branches of the orchard trees prevents the formation of carbon by the action of the sun's rays upon the carbonic acid of the potato plant."—*Library of Useful Knowledge*, article "Botany."

* "If," says De Candolle, "two plants are exposed, one to darkness the other to the sun, in close vessels, and in an atmosphere containing a known quantity of carbonic acid, and are removed at the end of twelve hours, we shall find that the first has diminished neither the quantity of oxygen nor of carbonic acid; and that in the second, on the contrary, the quantity of carbonic acid has diminished, while the quantity of free oxygen has increased in the same proportion. And if the experiment is conducted with sufficient care, we shall discover that the plant in question has gained a proportionable quantity of carbon. Therefore the carbonic acid which has disappeared has given its oxygen to the air, and its carbon to the plant, and this has been produced solely by the action of solar light."

However varied experiments may be they all lead to the same result, and compel us to acknowledge the great importance of light to plants, in enabling them to digest the crude matter which they gain from the

These and similar observations shew the necessity that exists for a knowledge of the construction, the nature, and the wants of plants, to those whose business it is to cultivate them, and when we consider that agriculture has from the commencement of the world been the occupation of a very large portion of its inhabitants, we may be surprised at the apparently small progress that has been made towards improvement, and this very reason has been adduced by some to shew that no improvements can be made in it. Necessity is the mother of invention; and where the world is but thinly populated, and where there is abundant space on which to produce food for the nourishment of its inhabitants, the old system of tillage is all that is necessary; perhaps, indeed, the very best that can be employed; and to those who are wearied with the constant struggle to keep their situation amongst a host of hungry competitors, it may seem a delightful solace to turn to the patriarchal ages, — those happy times when the son fol-

soil. In fact there is nothing of which we have any certain knowledge which interferes with these conclusions. We see in practice that the more plants are exposed to light, when growing naturally, the deeper is their green, the more robust their appearance, and the greater the abundance of their odours, or resins; and we know that all the products to which these appearances are owing are highly carbonised. On the contrary, the less a plant is exposed to sun-light, the paler are its colours, the laxer its tissue, the fainter its smell, and the less its flavour. Hence it is that the most odoriferous herbs are found in greatest perfection in places or countries in which the sun-light is the strongest.

lowed in the footsteps of the father from generation to generation. To the farmer those halcyon days have, perhaps, continued longer than to others, but with an enormously increased, and constantly increasing, population comes the necessity for change in the means of providing for it, and the produce of the soil must be increased; and, doubtless, it can be so to a very great extent. The more we consume in a country, the more we can produce; because, although consumed, the elements are not withdrawn from the soil: part has been dissipated in air, part in water, and part has returned to the earth; but that which the air has absorbed can be reclaimed from it again, that which has become water may again be furnished from the water, and that which has returned to earth can be reproduced from it. Man can neither create nor destroy one atom of elemental nature, still, by bad management, he may render a great portion of valuable matter useless for ages to the purposes of life, by allowing it to descend streams and rivers, and at last fall into the ocean, from whence centuries may elapse before it can be reclaimed. It would almost appear a provision of nature that food should be grown in the land where it is consumed, because any other arrangement seems contrary to those laws which regulate the natural circle of elementary particles. If one portion of the globe is to be confined to agriculture, to grow corn for the support of a

manufacturing population in a distant hemisphere, the soil of the one will become in process of time impoverished and sterile, whilst the other will have an over-abundance of richness, and to restore the equilibrium it would be necessary to export manure.*

The study of the agriculturist should be to consider what are the elements required to bring the seed he is about to commit to the soil to perfection, what portion of these it will obtain from the soil, what from the water, and what from the atmosphere, and if any deficiency remains, to supply it by carrying on *that* species of manure which contains the wanting particles. Nor must he forget to take into consideration all the circumstances of temperature, light, and situation; having made this provision, he will have done the best that human foresight can do to ensure a plentiful harvest.

The practical farmer will, perhaps, smile at this

* "Can the art of agriculture be based upon any thing but the restitution of a disturbed equilibrium? Can it be imagined that any country, however rich and fertile, with a flourishing commerce, which for centuries exports its produce in the shape of grain and cattle, will maintain its fertility if the same commerce does not restore, in some form of manure, those elements which have been removed from the soil, and which cannot be replaced by the atmosphere? Must not the same fate await every such country, which has actually befallen the once prolific soil of Virginia, now in many parts no longer able to grows its former staple productions—wheat and tobacco?"—LIEBIG's *Letters on Chemistry*.

theory, and say he has never failed in producing a good crop, although quite ignorant of the elements of which it is composed; but though he may be ignorant of their names, he has proved himself thoroughly acquainted with their properties by the success of his labours, — that success has been the result of his inquiry and experience, and he has by it arrived at the conclusion, that certain manures and certain treatment are best suited for the production of certain crops; and if he were to examine these manures chemically, he would find they contained the elements required.

# CHAPTER V.

## THE KITCHEN.

"He that gives his mind to observe will meet with many things, even in vulgar matters, worthy of observation."—BACON.

"Some man's wit
Found out the art of cookery to delight his sense:
More bodies are consumed and killed with it
Than with the sword, famine, or pestilence."—DAVIES.

THE culinary art would give much scope for the researches of the philosopher were the occupation of a cook in better repute; but it has generally been considered too menial an employment for a man of intellect, and certainly when employed merely to tickle the palate of an epicure, it is well worthy of contempt, and the lines we have chosen for the head of this chapter seem to insinuate something of the same kind: this, however, is the abuse, and not the use, of cookery.

"But to their proper operation still
Ascribe all good to their improper ill."

Happily these ideas are fast giving way to more reasonable notions, and we find Philosophy entering

even into our kitchens; and why should it not?* It is not considered below the dignity of science to examine into the produce of the farm, and those have been ranked amongst the greatest benefactors of mankind who, by their researches, have most contributed to the improvement of agriculture and the production of food for man. Now as these products cannot be used as food till they have passed through the kitchen, I can see no reason why he who best contributes to economy and frugality in the preparation of food is not entitled to his meed of praise. And this is, perhaps, a more important subject than we generally consider it to be; for as much may be wasted by a bad manner of preparing food as can, perhaps, be saved by the farmer's economy in producing it.

The manufacture of bread, as being the most im-

* The term Philosophy is said to have originated from the modesty of Pythagoras. Learned men before his time were generally designated sages or wise men; thus we have the seven wise men of Greece. It is narrated that Pythagoras being questioned by Leon, who had been charmed by his ingenuity and eloquence, in what art he principally excelled, replied that he did not profess himself master of any art, but that he was a Philosopher. Leon, struck with the novelty of the term, asked Pythagoras who were philosophers, and in what they differed from other men? He replied that, as in the public games, whilst some are contending for glory, others are buying and selling in pursuit of game, there is always a third class of men who attend only as spectators. So in human life, amidst the various characters of men, there is a select number who, neglecting all other pursuits, assiduously apply themselves to the study of nature and the search after wisdom. "These," added Pythagoras, "are the persons whom I term Philosophers."

portant process, will first attract our attention; and let us see how the operation is proceeded with. A mixture is made, consisting of a portion of water, yeast, flour, and a little salt. After kneading it for a short time, it is placed before the fire to rise; it is afterwards transferred to the oven and baked, and the operation is finished. The most curious part of the process is the action of the yeast in causing the bread to rise. Flour contains a small portion of saccharine matter, the addition of yeast to which produces fermentation, in the same manner that it does in brewing. During this fermentation an air, called by chemists carbonic acid gas, is evolved. Now the glutinous substance of the dough will not allow this air to escape; but we find it pervading the whole mass in minute bladders, forming it into a light spongy substance. The warmth of the fire has a double action, first by increasing the inclination to fermentation in the dough, and secondly, by the heat expanding the air in these small bladders, rendering the paste still more porous. Were the dough removed from the fire it would, as the bakers express it, fall—that is, the cold would condense the air in these small globules, and render the mass close, and consequently heavy; for although the heat of the oven will again expand the air, the dough may have acquired so great a solidity as to resist this expansive force, and it will therefore remain heavy. The use

of yeast is to render the bread light, by separating its particles. Knowing this, it is not difficult to substitute some other material to produce the same effect, when yeast cannot be procured; and, perhaps, none is more efficient and simple than the mixture of muriatic acid and carbonate of soda, in such proportions as to neutralise one another, when they form that useful article, salt; for salt is a natural production consisting of these two substances, and it is from the decomposition of salt, or muriate of soda, that these substances are manufactured. When muriatic acid and carbonate of soda are mixed together, they give out carbonic acid gas; and as this mixture takes place in the dough, the gas pervades the whole mass in the same manner as if formed by the yeast, and their residuum being merely a small portion of common salt, which is always required in making bread, is of no consequence. If the proportions are well kept between the acid and soda, there can hardly be a better substitute for yeast, or one that will yield a purer bread.*

In our chapter on the breakfast-parlour we spoke

* One pint and a half of cold water, half an ounce (troy) sesqui-carbonate soda, five fluid drachms muriatic acid, two thirds of an ounce of salt, and three pounds of flour. Dissolve the soda in half the water, mix the muriatic acid with the remainder. Let the soda and water be mixed well with the flour, then add the acid and water, stirring it quickly with a wooden spoon (rather thin mixed), put it immediately into a hot oven, and bake it an hour and a half.

of the difference of surfaces in giving or receiving heat; and here this subject may be studied to much advantage and economy. The bright tin screen which is placed behind the meat while roasting, to reflect the rays of heat back upon the meat, instead of allowing them to be dispersed, is of double advantage, in confining the heat to the part where it is required, and preventing the kitchen becoming unpleasantly hot. Had a black surface been employed instead of the bright tin, how different would have been the effect! the black surface would have absorbed the rays of heat instead of reflecting them back on the meat, and much firing would have been consumed in vain.

Hence it appears that there are many of the operations of the kitchen conducted on solid philosophical principles; but we now come to one of which the benefit is less apparent, although, from the universality of the practice, one is inclined to fancy there must be some advantage derived from it. I allude to the custom of placing an inverted cup in a fruit-pie, as the cook will inform us, to contain the juice whilst the pie is baking in the oven, and prevent its boiling over; and she is the more convinced in her theory, because when the pie is withdrawn from the oven the cup will be found full of juice. When the cup is first put in the dish it is full of cold air, and when the pie is placed in the oven, this

air will expand by the heat and fill the cup, and will drive out all the juice and a portion of the present air it contains, in which state it will remain till removed from the oven, when the air in the cup will condense and occupy a very small space, leaving the remainder to be filled with juice: but this does not take place till the danger of the juice boiling over is past. If a small glass tumbler is inverted in the pie, its contents can be examined into whilst it is in the oven, and it will be found what has been advanced is correct. Our own cook was very sceptical on this head till she tried this experiment.

Almost all substances alter their nature and their properties at different degrees of heat, and a knowledge of the temperature at which these variations occur may be found very useful in culinary affairs. For instance, below 32 degrees of the thermometer water becomes a solid, above 212 it becomes an elastic vapour. When mixed with other substances the boiling point varies, and approaches nearer to the boiling point of the substance with which it is combined. By taking advantage of this we can separate two substances which have been mixed, or render the mixture stronger or weaker; as, for instance, when boiling a syrup of sugar and water, the more we boil the stronger the syrup will become; but if we boil any fermented liquid, such as wine or spirits, it will lose its strength the longer we boil it.

The reason for this is, that the spirituous part is transformed into steam at a lower temperature than water is; it therefore flies off first, leaving the water behind; whereas, with the syrup the water is converted into steam, leaving the sugar behind.

Liquids during the process of heating are in a constant course of circulation; as the lower part absorbs heat it becomes lighter, and ascends to the surface, whilst the colder and heavier parts sink to the bottom, to acquire fresh heat and then to ascend to the top. If we try to heat water from the surface we shall find that no circulation is caused; the upper portion will become warm, but the lower parts being the coldest, and consequently heaviest, will remain at the bottom: the process of heating will, therefore, proceed very slowly. On the contrary, if we wish to cool a liquid it will be most effectual to apply the cold to the upper surface, because the cold part will descend, allowing the warmer parts to rise and come in contact with the cooling substance.

A piece of ice at the bottom of a deep glass of hot water will remain long unmelted, but if brought to the surface it will speedily be dissolved, as we found to be the case with the lump of sugar in the tea.

Whilst considering the subject of cookery we must not forget the art of brewing, the proper conducting of which depends much upon chemical knowledge;

for though there are many who brew, and brew well too, who know not even the meaning of the word chemistry, still, as we have before remarked with regard to the farmer, it will be found that their experience has taught them chemistry unknown to themselves, or rather, their system of proceeding will be found to be based on chemical data, and will bear the test of philosophical inquiry.

Countries to which Nature has denied the richer juice of the grape as a natural production, have in all ages cultivated some kind of substitute. Hence, from Egypt is said originally to have been derived barley-wine: we have, therefore, antiquity in its favour. But it is not the use or the abuse of the beverage that we are about to discuss; we will only make a few remarks on the phenomena developed in its production, of which fermentation is the greatest and most important, as the agent which transmutes the saccharine matter, or sugary principle of the malt, from a mere syrup, as it may be considered when in the first state of *sweet-wort*, into a *spirituous* liquid. We are indebted to Lavoisier as the first who offered any thing like a theory of the process; and although his theory may be now considered as very incorrect, still it laid a foundation for a more accurate examination of the subject, of which the following may be considered as the brief result: A weak solution of sugar and water will of itself

ferment, if kept in a warm place; as will also, and more readily, the sugar contained in grapes and the saccharine matter of malt.

In a general view of fermentation, therefore, we will leave out the small quantity of yeast employed, because it is not absolutely necessary, but seems merely to render the effect more rapid, and thus to prevent the change of the liquid into acidity. In complete fermentation, the sugar disappears altogether, and two new substances are formed in its place, carbonic acid and alcohol. The carbonic acid gas escapes whilst the beer is left open, which may easily be tested by holding a lighted candle near the surface of a tub of beer whilst at work, when it will quickly be extinguished, proving also the deadly nature of the air. The alcoholic part remains in the liquor, which has become specifically lighter, from the decomposition of the sugar, and in large breweries the fermentation is regulated according to the specific gravity attained. If too much of the carbonic acid gas is driven off before the cask is bunged down, the beer will become flat, and it will be a long time before it acquires briskness. It is this which occasions the beer to become flat when the vent-peg is left out, by allowing the carbonic acid gas to escape; but of this vent-peg we shall say a little more presently, under the head of atmospheric pressure.

The use of hops in beer, besides the flavour they communicate, is to render it clear, and also as a preventive from its becoming acid. The hop coagu lates the excess of mucilage, and glutinous matter, which is extracted from the malt in mashing, and which matter, if allowed to remain in solution in the beer, would effectually prevent its becoming fine and clear.

Fermentation, though producing such beneficial effects in the manufacture of beer and wine, when arrested at its proper stage, is nevertheless the first step in the process of decay in animal and vegetable matter; and science has rendered a great benefit to mankind in shewing us how this process can be effectually suspended for almost an indefinite period by subjecting the matter, whether animal or vegetable, to the boiling heat in vessels hermetically sealed. By this process the action of the oxygen in producing decomposition is stopped; and as no fresh oxygen can enter, the contents of these vessels are preserved, and will remain so for any length of time.

The preservation of meat and vegetables on this principle is now carried on to a great extent for the use of ships on long voyages, which can thus be supplied with fresh meat and vegetables, although thousands of miles distant from the place of their production, and under the heat of a tropical region.

The same means might be very effectually employed in domestic management, were those persons intrusted with the execution of such operations better informed of the principles on which they act. How many failures attend the preservation of fruit, which may almost invariably be attributed to the want of a proper knowledge of the decaying principle! Bottles of gooseberries are boiled, and by that means fermentation prevented; but before they are properly secured or hermetically sealed, they are, perhaps, allowed to imbibe a fresh supply of air, which will speedily undo all that has been done, and fermentation will certainly ensue. Whereas, had the bottles been effectually closed by rosin or wax, before they were removed from the boiling fluid in which they were immersed, their preservation would have been insured. It is to this part of the process that the whole of the attention is required, for the smallest air-hole is sufficient to produce a failure.

With meats, or vegetables preserved in tin boxes, the difficulty is less, because they can be properly soldered before being put into the hot water, there being no danger of bursting them. But with glass bottles the case is much more difficult, because if secured beforehand they would infallibly burst, if the heating operation was effectually performed. The best method appears to be to put the corks lightly into the bottles, and, when the contents have become

thoroughly expanded, to drive the corks home; then continue the operation of boiling a short time longer, and as they are one by one removed from the boiling water, to turn their necks quickly into a ladle of melted rosin. Many cooks in doing this would take out all the bottles at once, and then commence sealing them, by which means the contents of the bottles would have begun to cool, thus forming a partial vacuum. Now if the cork is not perfectly tight, which it is hardly likely to be, air will be drawn in to fill this vacuum; and after having carefully sealed the bottle, we shall have succeeded in shutting in the enemy also, who will soon give notice of his presence by the fermentation which will ensue.

Hence it appears that fermentation is the earliest symptom that oxygen, the great agent in the process of decomposition, which exerts its influence on all animal and vegetable matter, as soon as the vital principle has ceased to act, has commenced its triumph over the fallen; for fermentation, putrefaction, and decay, follow fast on one another, resolving what was once a living form again into its original elements, fulfilling the words of inspiration, "Dust thou art, and unto dust shalt thou return." And though we may at a first glance consider decay as an unseemly object to be presented to the lords of the creation, we must not forget that it is only the completion of the circle

in which all created things move. Nothing terrestrial is free from mutation; but though constantly changing, we have the pleasing contemplation that the decay which we lament is the harbinger of renewed beauty and life, an emblem of the glories of immortality.

## CHAPTER VI.

### THE STUDY.

"Hast thou no friend to set thy mind abroach?
Good sense will stagnate. Thoughts shut up want air,
And spoil, like bales unopened to the sun."—Young.

In our last chapter we examined a few of the most prominent phenomena of the kitchen; now that we have arrived in the study, we shall be able to illustrate some of them still further; and as the pressure of the atmosphere is one of the great agents in producing many of the effects that will come under our consideration, we will devote a part of this chapter to the subject. And here I must apologise to my young reader for requiring somewhat more of his attention than I have yet demanded; for, though the subject is not very difficult to comprehend, it will require a considerable degree of thought to adapt it to all the various modes in which it will be presented to his view: he will, however, find himself well repaid for the time he may devote to it.

Atmospheric pressure is the weight of the air

resting on the surface of the earth; air extends to a height of many miles above the earth, and, although but a light fluid, yet so great an altitude of it must be of considerable weight. Were we to take a square tube, one inch in diameter inside, and so many miles high as to reach to the top of the atmosphere, the air in that tube would weigh about fifteen pounds: therefore every superficial inch of the earth's surface is pressed upon by a weight of fifteen pounds. Now air being a fluid, presses in all directions alike, consequently every surface which is exposed to its action, whether it be horizontal or perpendicular, or in whatever direction it may be placed, is subject to this pressure. The idea very naturally suggests itself, How is it that we are not sensible of this enormous weight, for fifteen pounds on every inch of the surface of a man's body would amount to many tons? The secret, however, consists in the pressure being exerted not only externally, but internally, and it is therefore balanced and rendered insensible to us; but, should any thing occur to disturb this equilibrium, we are immediately made sensible of the pressure. Suppose we take a sheet of writing paper stretched on a hollow frame, and press a book against it on one side, whilst another book is pressed against it on the other, no effect will be produced; but if we remove one book, the equilibrium is destroyed and the paper gives way under the pressure, which before

was imperceptible to it. Just in the same manner is the pressure of the atmosphere rendered imperceptible, whilst counterbalanced by a corresponding pressure on the opposite side.

If we place our hand over the open receiver of an air-pump and exhaust the air from beneath, we shall very quickly be made painfully sensible of this pressure; or if we tie a bladder over the glass, instead of placing the hand there, and again exhaust the air, the bladder will burst. But a still more simple experiment, to shew the weight of the atmosphere, may be made in the following manner:—Fill a wine-glass with water, and cut a piece of writing paper nearly to fit the top of the glass; lay the paper on the glass, which should be quite full; then, placing the palm of the hand over the paper, gently invert the glass and hold it bottom upwards. The palm of the hand may then be removed, and the paper will be pressed against the mouth of the glass by the atmosphere, so as to prevent the water from falling out, the pressure above being removed by the bottom of the glass. The use of the paper is to give a sufficiently dense medium to allow the air to press against the water.

"The atmospheric pressure on living bodies produces an effect which is rarely thought of, although of much importance, viz. keeping all the parts about the joints firmly together by an action similar to that

exerted on the Madgeburg hemispheres.* The broad surfaces of bones forming the knee-joint, for instance, even if not held together by ligaments, could not, while the capsule surrounding the joint remained air-tight, be separated by a force less than about a hundred pounds; but on air being admitted to the articular cavity, the bones at once fall to a certain distance apart. In the loose joint of the shoulder this support is of great consequence. When the shoulder or other joint is dislocated, there is no empty space left, as might be supposed, but the soft parts around are pressed in to fill up the natural place of the bone. When a thigh-bone is dislocated, the deep socket, called the acetabulum, instantly becomes like a cupping-glass, and is filled partly with fluid and partly with the soft solids. In all joints it is the atmospheric pressure which keeps the bones in such steady contact, that they work smoothly and without noise."—Arnott's *Physics*, p. 349.

* The Madgeburg hemispheres here mentioned are merely two hollow iron cups, the edges of which are fitted so close that, when put together, they form an air-tight, hollow ball; the air being withdrawn from them by an air-pump, connected with the interior through the handles of the cups, they are pressed together by the external atmosphere, with a pressure of fifteen pounds on every inch of surface in the mouth of the cups. This experiment was the invention of Otto de Guericke, and was one of the first that drew attention to the material nature and properties of air. These hemispheres were considered so great a wonder, that it is recorded that the Emperor was present on the occasion of a public exhibition of them, when six of his coach-horses were required to pull them asunder.

The vent-peg, which we promised to explain in the last chapter, is another familiar illustration of this subject. When a cask is bunged close down, the pressure of air is removed from the surface of the liquid by the intervention of the cask, but when the tap is turned, to allow the beer to escape, the pressure is suffered to act on the lower surface of the beer in the cask, through the tap, and the consequence is, the beer will not run out till the vent-peg at the top is removed; this immediately restores the balance of pressure, and the weight of the beer causes it to escape.

The common pump, again, is a most useful application of this pressure to domestic purposes. As we have before stated, every inch of surface supports a weight of fifteen pounds. Now, if we can remove this fifteen pounds from one inch of the surface of the water in a well, whilst we allow the pressure to remain over the other part, it follows, that the water will be forced up in the part from which the pressure is removed; and if the water so forced up be enclosed in a tube, an inch square, we shall find that it will rise in this tube till the quantity contained in it will weigh fifteen pounds, which would require an altitude of thirty-four feet, the weight of water in the tube being equal to the weight of air on a similar surface of water in the well. The pump is an instrument for removing this pressure of the atmosphere from the

pipe. The piston of the pump is made to fit into the pipe leading to the well. Every time the piston is raised, it lifts the weight of the atmosphere resting upon it, removing its weight from the water in the pipe; the water from the well, therefore, follows up the pipe to fill the part from whence the weight is removed; and as there is a valve, or small door at the bottom of the pipe, which prevents the water returning into the well as the piston descends, every fresh stroke of the pump is followed by a fresh supply of water. This species of pump is called a sucking-pump, from its similarity to the action of animals in drinking. When an animal drinks, a partial vacuum is formed in the chest, or mouth, and the water flows up as in the pipe from the well. The ancients, who were well acquainted with the effects of atmospheric pressure, without understanding its cause, attributed it to Nature's abhorrence of a vacuum, which, though it might be to them a sufficiently satisfactory explanation, is not very definite to a scientific mind.

But of all the uses to which atmospheric pressure has hitherto been employed, its application to the purposes of drawing carriages on lines of railway is, perhaps, the most startling, and one which, should its success be established by longer experience and by a greater extent of line than it has as yet been employed upon, will produce a great change in the

present mode of railway traction. But the solution of this problem must be left to a future period, not perhaps very far distant, as a line of considerable length is now in progress, under the able superintendence of the celebrated engineer, Mr. William Cubitt. The question resolves itself into, which is the most economical? the short lines now worked on that principle leaving no doubt of its practicability. The plan on which the atmospheric railway is constructed is this: the rails are laid for the carriages to run upon as in a common railway, but between them is placed a continuous line of iron-pipes, about fifteen inches in diameter, with a groove or opening all along the top of them. Into this pipe is fitted a piston similar to the piston of a pump, and tightly packed with leather so as exactly to fill the pipe. The air being now exhausted, or pumped out by a stationary steam-engine at one end of the line, the pressure of the atmosphere, acting on the back of the piston, drives it with great velocity along the pipe, the carriages being connected with the piston by means of an upright iron rising from the piston through the groove or slit, which we have before mentioned, in the iron-pipe.

The most curious and ingenious part of the invention, is the means used to render this groove airtight, which is absolutely necessary, or it would be impossible to form a vacuum. This is contrived by

placing an india-rubber rope along the groove in a bed of wax and tallow. The iron attached to the piston lifts this rope or valve after the piston is passed, and thus connects the piston with the carriage, whilst a hot iron, following the train, replaces the rope and melts the tallow again, thus sealing all up and rendering it fit for the next train.

One great advantage of this species of motive power is, that it entirely avoids any concussion, as only one train can be in motion between the stations at one time. It also affords greater facilities for ascending inclined planes, or, as they are scientifically called, gradients, than the present locomotive engine; added to which, the weight of the engine travelling along the line is avoided.

It is not our object to determine its practicability on a long line of railroad, we only mention it here as a new, and certainly very clever, application of atmospheric pressure to useful purposes.

The foregoing examples of atmospheric pressure naturally lead us to the barometer, an instrument contrived for the purpose of ascertaining the variations of this pressure; for though we have stated it at fifteen pounds per inch, as its mean weight, it is subject to constant variation with every change of the atmosphere. The barometer is a glass-tube, close at the top; it is about thirty-three inches long, and is filled with quicksilver, and inverted in a cup con-

taining the same, the air being allowed to press on the surface of the quicksilver in the cup, as it did on the water in the well; and its weight being removed from the quicksilver in the tube by the end being closed. The mercury will now be supported in the tube to a height equivalent to the weight of the atmosphere. This, as we before stated, requires thirty-four feet of water; but as mercury is fourteen times heavier than water, it will require only one-fourteenth part of that length, or about twenty-nine inches. When the atmosphere is heavy, it presses with more force upon the surface of the mercury in the cup, forcing it higher up the tube; whereas, when the atmosphere is light, the pressure is relieved, and the mercury falls, thus causing a high or a low barometer; and, from constant observation, a high barometer has been found to indicate fair weather, as a low one to denote storms and rain.

The reasons for the barometer indicating these coming changes in the atmosphere may be partially explained here, but it would far exceed the limits of our little work were we to enter into a full detail of all the various theories on the subject. It must be remembered, that the storm is but the effect; and that, as we have said before, there is no effect without a cause; the same cause, therefore, that is producing the storm, is operating on the barometer.

In order to explain this, we will suppose that a sudden alteration of temperature has condensed the water that was before suspended in an invisible vapour, and caused it to descend in rain; this will have the effect of reducing the weight of the atmosphere, and, consequently, diminishing its pressure. Now, as this does not operate over the whole globe, it follows, that the air, from those parts where there still remains a heavy pressure, will immediately rush to the part where the pressure is less to fill up the vacuum, thus producing storms of wind; and the more sudden the reduction of pressure, which will be denoted by the rapid falling of the barometer, the more violent may we expect the storm to be.

"To the husbandman the barometer is of considerable use, by aiding and correcting the prognostics of the weather, which he draws from local signs, familiar to him; but its great use as a weather-glass seems to be to the mariner, who roams over the whole ocean, and is often under skies and climates altogether new to him. The watchful captain of the present day, trusting to this extraordinary monitor, is frequently enabled to take in sail, and to make ready for the storm, where, in former times, the dreadful visitation would have fallen on him unprepared. The marine barometer has not yet been in

general use for many years, and the author was one of a numerous crew who probably owed their preservation to its almost miraculous warning. It was in a southern latitude. The sun had just set with placid appearance, closing a beautiful afternoon, and the usual mirth of the evening watch was proceeding, when the captain's orders came to prepare with all haste for a storm. The barometer had begun to fall with appalling rapidity. As yet the oldest sailors had not perceived even a threatening in the sky, and were surprised at the extent and hurry of the preparations; but the required measures were not completed when a more awful hurricane burst upon them than the most experienced had ever braved. Nothing could withstand it; the sails, already furled and closely bound to the yards, were riven away in tatters, even the bare yards and masts were in great part disabled, and at one time the whole rigging had nearly fallen by the board. Such, for a few hours, was the mingled roar of the hurricane above, of the waves around, and of the incessant peals of thunder, that no human voice could be heard, and, amidst the general consternation, even the trumpet sounded in vain. In that awful night, but for the little tube of mercury, which had given the warning, neither the strength of the noble ship, nor the skill and energies of the commander, could have saved one man to tell the tale. On the following morning the wind was

again at rest, but the ship lay upon the yet heaving waves, an unsightly wreck." *

From the ease with which we move about in air, we are very apt to consider it to be a fluid hardly capable of exerting resistance; but, when confined in an india-rubber bag, we shall find it to be a very solid substance, so much so, that if blown out pretty full we can produce little effect in condensing it by any pressure we can by our own weight put upon it. By inverting an empty wine-glass in a tumbler of water, and forcing it down, the air in the wine-glass will prevent the water from entering it more than a little way up the mouth, thus shewing its powers of resistance. It is upon the principle of air excluding the entrance of water that the diving-bell is constructed, which, as connected with this subject, shall be next explained.

The diving-bell much resembles the glass inverted in the tumbler, with seats placed round the inside of it, for the divers to sit upon, the bell, therefore, descends to the bottom of the ocean, filled with air sufficiently dense to prevent the water flowing up in it. This air would soon be rendered unfit to exist in, from the respiration of the divers; two pipes are therefore connected with it from above,

* ARNOTT's *Physics*. "The marine barometer differs from that used on shore in having its tube contracted in one place to a very narrow bore, so as to prevent that sudden rising and falling of the mercury which every motion of the ship would else occasion."

the one for the escape of the vitiated air, and the other for the purpose of forcing in a fresh supply. The air in the bell is always in a condensed state, and the lower it descends the greater will this condensation be, from the weight of the water accumulated above it.

The effects of this pressure of water was very curiously exemplified, a few years ago, by some gentlemen who were trying experiments on water brought from different depths of the ocean. For this purpose they had corked up an empty bottle, which they lowered into the sea, imagining that when the pressure was sufficient, it would force the cork into the bottle, and that the bottle would fill, so as to bring them a specimen of water from that depth; but what was their surprise on pulling up the bottle to find it still corked, although full of water. They now began to conjecture that the water had forced its way through the pores of the cork; and, to prevent this, they *sealed* the cork of the next bottle. On pulling this up, however, the mystery was solved—the bottle was found to be full, and corked as before, but the cork was reversed, and was forced into the neck of the bottle, with the sealed end inside. This curious fact was thus accounted for:—As the bottle descended, the pressure drove the cork in, and filled the bottle; the cork floating close up in the neck, the weight of the sealing-wax on the top causing it

to reverse its position, and float with the sealed end downwards; when the bottle was drawn up, the pressure being diminished, the water, or perhaps more properly speaking, the slight portion of air contained in the water, expanded, and forced the cork again upward into the neck of the bottle. All this appears simple enough when explained, but it required a good deal of consideration on the part of those who first witnessed this experiment.

Another, and perhaps one of the most deserving our attention of all natural phenomena, but which, nevertheless, from the constancy of its occurrence, is rarely noticed, is gravitation or weight, that is, the tendency that all bodies have to fall to the earth, or rather to be attracted to it; for we shall endeavour to explain that gravity, weight, and attraction, are one and the same thing. All bodies appear to have a natural proneness to draw together or attract one another, according to their relative magnitude or weight; but this quality is so hidden from us by counteracting agencies as to render it often invisible.

The earth being so immensely larger than any of the substances that are capable of movement upon it, forms the first grand attracting mass, and the weight of any object resting upon it, is exactly the force that is required to overcome this attraction. Attraction and weight, therefore, are synonymous terms. Now, as the earth is a globe, and we are on the

surface of it, it follows that the greatest attracting force must be in a line from us, through its centre, because that is the direction of its greatest bulk. We find, therefore, that a stone falls perpendicularly, or in a direction to the centre; but were a hole bored entirely through the earth, and we were to drop a stone through it, it would fall no farther than the centre, where it would hang suspended, the quantity of matter above being equal to the quantity beneath. Gravitation or weight would here cease, and the stone would remain at rest, the attraction on either side being exactly balanced. It often puzzles the infantine mind—when first informed that the world we live on is a globe, and that it is inhabited on all sides—how it is that the inhabitants do not fall off in the same manner that any substance would fall from the under-side of an orange if attempted to be placed thereon; and though we soon become convinced of the fact, it requires an acquaintance with the laws of attraction, to render it clear to our reasoning faculties when exerted upon it.

Though the magnitude of our globe prevents our making any experiments on perpendicular attraction or weight, because, as before stated, it is so much larger as to exclude any opposing attraction to be brought in competition with it, still we can exemplify our meaning by one or two simple examples of horizontal attraction, shewing the inclin-

ation large bodies have to attract smaller ones. Let us examine the bubbles on the surface of a cup of tea, and we shall find them all arranging themselves round the sides of the cup, attracted by the superior mass; or if we disengage a large bubble, we shall find the smaller ones in its vicinity approaching and attaching themselves to it, as their superior planet. If we contrive to draw this large bubble to the centre of the cup, which may be easily done by moving the spoon before it, thereby attracting it, and leaving it exactly in the centre, we shall find it will remain there till some little movement causes it to approach nearer to one side of the cup, when the balance of attraction is destroyed, and it immediately passes to the side of the cup nearest to it. We often see the water near the sides of a quiet pond covered with leaves and light substances, whilst the centre is quite clear. The superior attraction of the shore having influenced every lighter substance, and brought them under its power.—Not an unapt similitude to the lighter characters of mankind, who we find arranging themselves round those of strong and vigorous mind, forming the nucleus, which swells and become more and more preponderating as the mass increases in bulk and magnitude.

These instances explain horizontal attraction, which resembles perpendicular attraction in all but position; but there being nothing sufficiently ponderous to coun-

terbalance the immense globe beneath our feet, the attraction here must always be one way, downwards, when it takes the name of gravity or weight. Were a planet larger than our earth to approach very near to us, we should find, as it approached, all the loose substances, ourselves amongst the foremost, leaving our own planet and flying to the superior attraction; weight would be at once destroyed, or rather overcome by its antagonist's power, and, like the bubble on the surface of the cup, all matter would fly to the greater body. We have supposed this case merely to shew more plainly our meaning, but it must be remembered that were two planets so to approach one another as to overcome the other resisting agencies, which held them in their sphere, they would rush together, and form one mass, impelled by the very power of attraction of which we are speaking.

The tides are an instance of this power exerted over us by distant planets—being caused by the attraction of the moon and sun; which exerting their attractive influence over the liquid, and, consequently, movable portion of the globe, causes the waters more immediately below them to be heaped up, producing a wave or tide.

The earth, as she revolves, presenting constantly a new part more directly under the moon's influence,

causes every portion of the sea to be thus elevated once in the twenty-four hours. The tide, however, rises and falls twice in that time, which is accounted for by the theory that the drawing together of the waters on one side of the globe causes a disarrangement of its parts, which is compensated for by a corresponding protuberance on the opposite side. Thus there is one tide of attraction, and one which results from it, to bring back the equilibrum. The sun also exerts a similar influence, though, from its greater distance, in a minor degree. When the sun and moon, therefore, are in nearly the same position, by exerting their united influence, they elevate the tide wave to a still higher level; the same effect it is obvious must be produced when these planets are nearly in opposition to one another, because then the secondary tide, which we before mentioned as resulting from the first, or tide of real attraction, is acted upon by the opposite planet; and as the moon and sun are alternately in opposition and conjunction twice in every lunar month, that is at full and new moon, we have at those periods higher tides, called spring-tides; whereas at the quarters of the moon, when they exert their influence at right angles to one another, the tides will be much less, and are called neap-tides.

The little diagram, in which the dark circle

represents the earth, and the dotted line the supposed tide-wave, will shew this phenomenon still plainer.

Fig. 1. Spring-Tides.

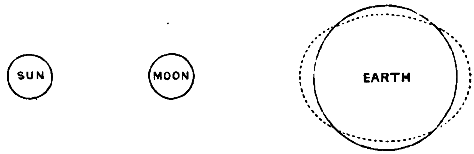



Fig. 2. Neap-Tides.

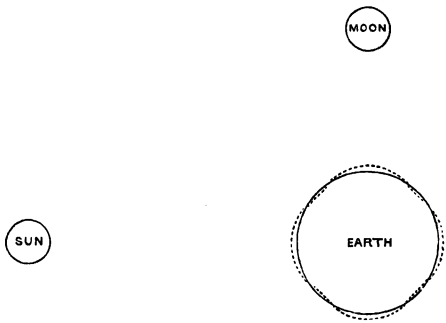



Fig. 1 represents the moon and sun in conjunction, as at new moon, occasioning spring-tide. Fig. 2 shews the moon at her first quarter, where it will appear that the attractive power of the two planets tends to neutralise one another, causing neap-tides. Were the attractive power of the sun and moon equal, there would at this latter time be four tides; that is, two of the sun, and two of the moon; but as the

moon, from its greater proximity, is by far the most influential, the effect produced by the sun is visible only in diminishing the lunar tide, and not by producing an independent tide of its own. It will be clear, also, that the higher the tide rises in one place the lower it must ebb in another, and consequently we find that the spring-tides rise higher and fall lower than neap-tides, which approach nearer to an equilibrium.

The various positions of headlands and continents greatly interfere with the regularity of the tides, which in some places are so at variance with this law of nature, that a superficial observer would be led to doubt the fact, which, however, on deeper research, would, perhaps, be found its strongest confirmation. The same power that draws the tiny bubble on the tea-cup to its larger neighbour, pervades all space, and holds the planets in their appointed course. How beautiful is every atom of creation, and how wonderfully may the mind of man be led from contemplating its smallest works to a glimpse of those laws which regulate its greatest movements, for the law is as perfect in the atom as in the universe!

## CHAPTER VII.

### THE SUMMER'S EVENING.

**" At summer's eve, when Heaven's ethereal bow**
**Spans with bright arch the glittering hills below,**
**Why to yon mountains turns the musing eye**
**Whose sun-bright summits mingle with the sky ?**
**Why do those cliffs of shadowy tint appear**
**More sweet than all the landscape smiling near ?"**

**CAMPBELL.**

MY readers will pardon me for having so suddenly shaken off the chill, cold garb of winter, and turned to the genial breath of summer, but the phenomena which we propose investigating in this chapter do not all occur during winter, and they will be much more pleasantly examined in our ramble through the flowery meads, than they could have been during the short evening of a winter's day. We will, therefore, bend our steps by the glassy margin of some silvery stream, and we shall presently be struck with the beauty of the reflections of the trees and cottages which diversify the opposite shore; we may, perhaps, be puzzled to account for seeing the reflection of the objects which are a considerable way removed from the banks; for the

image of a person, we are sensible, is not seen by himself unless he bends perpendicularly over the stream.

In reflection, the ray of light which strikes the water, or whatever reflecting object it may be, is always thrown off again at the opposite angle from that by which it arrives, and, therefore, to be seen by the person causing the reflection, he must be perpendicularly over it, or otherwise the ray will be projected in a different direction from him, and not come to his eye. Reflection follows the same law that a ball does when it rebounds from a hard substance. If we strike a ball perpendicularly against the floor, it rebounds again to our hand, as our reflected image is thrown back from the water to the eye; but if we throw the ball obliquely on the ground, it rises from the ground obliquely on the other side, just as the ray of light from the trees or cottage on the other side of the river may be considered to be thrown on the surface of the water, when it bounds off again in our direction, striking the water exactly at that part where a line drawn from the cottage to the water, and another from the water to our eye, would both approach the water at the same angle, though from different sides. A person stationed in the cottage would see our reflection, whilst we should see his. In the same manner, we do not see our own reflection in a looking-glass

except when we are opposite to it; but if we stand on one side of the glass, we see the reflection of persons standing on the opposite side. The annexed diagram will explain this subject more clearly.

The view represents a house a short distance from the bank, on one side of a river, whilst the spectator is standing on the opposite bank. The dotted lines represent the rays of light as they first strike the water, and are from thence reflected to the eye of the observer. The angle at which these lines touch the water is termed the angle of incidence, and that at which they again leave the surface and meet the eye, is called the angle of reflection, which two angles are always alike.

The reflected landscape appears inverted, because the more elevated objects strike the water, and are again projected from it more perpendicularly than

those below them. Thus the ray from the roof falls on the reflecting surface nearer to the observer than the ray from the lower part of the building, and the image is, therefore, inverted, resembling a picture laid before the spectator in a reversed position.

The effects of reflection are too beautiful, and too often brought under our notice, to pass unobserved by the most careless. They form a very prominent attraction in lake scenery, where the shores rise in bold and towering majesty, occasioning great depth of shadow, whilst the stillness of the water, caused by the shelter afforded by the precipitous shores, renders the surface of that glassy smoothness which so materially contributes to the beauty and perfection of the reflected image, rendering every leaf and spray as distinct as in the reality; and each appearing on the surface of the lake with mathematical exactness, in that part where the angle of incidence, or the angle by which the ray from it touches the water, exactly equals the reflected angle, or that by which it leaves the water to arrive at the eye of the observer. The slightest ripple on the surface disturbs the clearness of the reflection, by causing these various rays to be blended and confused.

It is not uncommonly remarked, that when the reflections are very clear rain is at hand; and there may be some truth in the observation, inasmuch as the exceeding state of repose into which the elements

are sometimes hushed, previous to a heavy rain, particularly in thundery weather, renders the water so calm as to be very favourable for the purpose of beholding the beauties of reflection.

Another very curious circumstance may be observed: if we place a walking-stick in the river, we shall perceive the part under the surface appears bent, so as to give the idea that the stick is broken at the water's edge. This is caused by refraction; by which is meant, that the rays of light when passing through a dense medium become bent downwards in their passage, giving the appearance just mentioned. Even in passing through the air this effect is produced in a small degree, and astronomers are obliged to make allowance for it in their calculations when observing the apparent position of the heavenly bodies, as this effect of refraction prevents their appearing where they really are. For instance, the rays of the sun being bent downwards in their passage to us, he will appear to rise, and be visible, before he is actually above the horizon, the rays having been bent downwards in their passage through the atmosphere. This may be prettily exemplified by placing a shilling at the bottom of a basin, then walking backwards till the edge of the basin hides the coin from our view; if, still keeping in this situation, we get some one to pour water into the basin, we shall find the shilling become visible, al-

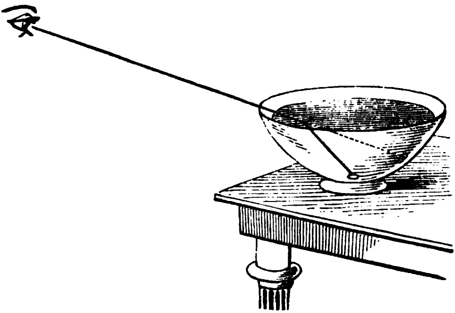
though it has not floated up in the basin, nor altered its position; but the rays of light, in passing through the water, have become bent so as to render the shilling visible. In like manner, the sun was visible before he had actually risen above the horizon.

"Certain states of the atmosphere depending upon its humidity, warmth, &c., change very considerably its ordinary refractive power; hence, in one state of it, a certain hill or island may appear low, and scarcely rising above the intervening heights or ocean, while in another state, the same object shall be seen towering above; and, from a certain station, a city in a neighbouring valley may be either entirely visible, or it may shew only the tops of its steeples, as if the bed on which it rested had sunk deeper into the earth. In days of ignorance and superstition, such appearances have sometimes excited a strange interest." *

* A very remarkable aerial phenomenon, caused by reflection and refraction, called mirage or fata morgana, is sometimes observed from the shores of the Mediterranean at a certain height in the atmosphere. The name, which signifies Fairy Morgana, is derived from an opinion of the superstitious Sicilians, that the whole spectacle is produced by fairies, or such like visionary, invisible beings. The populace are delighted whenever it appears, and run about the streets shouting for joy, calling every body out to partake of the glorious sight.

As soon as the sun surmounts the eastern hills behind Reggio, and rises high enough to form an angle of forty-five degrees on the water before the city, every object existing or moving at Reggio is repeated one thousand fold upon the marine looking-glass, which, by its tremulous motion, is as it were cut into facets. Each image passes rapidly off in

The little diagram, in which the upper portion represents the experiment before described of placing the shilling in the basin of water, and the lower



portion a town in a valley, in reality hidden from the eye of the observer by the intervening hill, but which has become visible to him through the means

succession as the day advances, and the stream carries down the wave on which it appeared. Thus the parts of this moving picture will vanish in the twinkling of an eye. Sometimes the air is at that moment so impregnated with vapours and undisturbed by winds as to reflect objects in a kind of aerial screen, rising about thirty feet above the level of the sea. In cloudy, heavy weather, they are drawn on the surface of the water, bordered by fine prismatic colours. But if the atmosphere be highly impregnated with vapour, and dense exhalations not previously dispersed by the action of the wind or waves, or rarefied by the sun, it then happens that in this vapour, as in a curtain extended along the channel, to the height of about four or five and twenty feet, and nearly down to the sea, the observer will behold the scene of the same objects not only reflected from the surface of the sea, but likewise in the air, though not so distinct or well defined as the former objects from the sea.

of a very highly refractive state of the atmosphere,

will exemplify these circumstances, and shew how the smaller experiment elucidates the natural effect alluded to; the operation of pouring water into the basin representing the more humid state of the atmosphere, which has caused its increased refractive power.

The eye is very much the creature of habit, much more so than we are accustomed to believe, till, being placed in some situation perfectly new to us, we become convinced of the truth of the assertion. Some years ago, coming rather suddenly amongst some mountainous scenery, to which the author was quite unaccustomed, he observed grazing on the hills, which did not appear far distant, some animals which, from their size, he mistook for goats, but upon a nearer approach they proved to be oxen; and having once become acquainted with the fact, the eye immediately adapted itself to the distance,

and he could not again be deceived in the size of the object; returning to the same place from whence he had first seen them, they no longer appeared the size of goats, but of full-grown oxen. Now, this clearly shews that the eye was unable to measure the size of the object, whilst the distance it was off, owing to the novel features of the scenery, could not be determined.

To exemplify this fact to some friends, he tried the following experiment from a window commanding a view down a beautiful river, on which vessels of considerable magnitude were frequently passing. Without mentioning what he intended to do, he cut out in paper, the picture of a vessel, with her ropes and sails, about one and a half inch in height, and pasted it on the middle of a pane of glass, in such a situation that looking through a paper tube, fixed to a screen on the other side of the room, the miniature ship appeared exactly in that part of the river where ships were usually seen sailing, and to occupy about the same visual angle. The paper tube prevented the observer from seeing the cross-bars of the window, which would have dispelled the illusion. Thus the deception was complete. The observers, ignorant of the contrivance, fully believed that they saw a large vessel sailing on the river.

This experiment may be rendered very amusing by adding a house or windmill, so as to appear as if form-

ing part of a distant prospect; or it might even be employed to test the effect of any intended improvement or alteration in a landscape: but it must be remembered that the observer must have no idea of the deception practised, or it will entirely fail in its effect. And care is required that the picture be so placed that it occupies the proper space, and also that there should appear no connexion between it and the window; or if suspended from any object, that the means of suspending it should be perfectly invisible: a mark across the glass would quite destroy the illusion.

It is this principle of keeping the spectator in ignorance of the distance the picture he is looking at is from him, that so greatly increases the deceptive effect of those beautiful exhibitions, the Dioramas and Panoramas, and other works of the same description, which are now carried to such wonderful perfection.

A person accustomed only to the scenery of England, with its trees and houses, and every well-known object rooted in his mind, is quite at a loss when first catching sight of the different description of buildings, trees, and scenery, that meet his view, on his arrival in the Eastern world, for a standard by which to measure their size; and generally imagines them to be not nearly so large as they are, till, approaching nearer, he discovers man, or some other familiar object, which at once serves as a scale by

which to estimate the objects presented to his view.

It is a general remark, that the first view of that vast and beautiful structure, St. Peter's at Rome, is almost always attended with disappointment, as not conveying the idea of its real magnitude, and that it seems to require repeated visits to impress upon the mind the vastness of its proportions. This, doubtless, arises from the want of a standard by which to regulate our judgment; for, on a first view, we do not perhaps sufficiently compare it with the human beings who may be walking under its lofty roof. Indeed, they appear too diminutive to draw our attention. It is only after the comparison has been forced upon us in some way, that we are fully aware of its colossal dimensions, and we then feel astonished that we could ever have been insensible to them.

That the eye retains the image of an object after it is withdrawn from our sight, may be often observed when walking briskly along a pretty closely-boarded fence, when the partial openings between the boards will give the effect almost of a continuous landscape; or, if we may so express it, we seem to see through the boards, the view that we have obtained through one opening not having faded from the eye till another has renewed it, thus producing a constant impression. In the same manner, by burning the

end of a stick, and then moving it round in a circle, we give the appearance of a wheel of fire, though, in reality, it is merely a spark so quickly returning as to give the effect of a circle.

Several curious toys have been constructed on this principle, of the eye retaining the image after the reality is removed, by drawing separate figures on a card, and causing them to revolve, so that first one and then another is presented to the eye, through an opening in a card placed before them. Thus, if a man be drawn on the upper portion of a circular card, and a horse on the lower part, both with their feet towards the centre, through which a spindle is passed, and the card be rapidly whirled round, the image of the horse and man, as they alternately present themselves before the opening in the front card, will have the appearance of a constant picture of a man on horseback. These combinations can be varied in many ways, forming a pleasing exercise for the ingenuity of young people on a rainy day.

The lengthened shadows serve to tell us that the bright luminary of day is fast sinking in the west, to enlighten another hemisphere, while the moon rising in the east is shedding her mild lustre around. These shadows remind us of the cause of lunar eclipses, and whilst in this situation present a happy illustration of that phenomenon. We observe our own shadow grows longer and longer, till at last,

when the sun is quite horizontal, the shadow becomes endless, and we might fancy it projected so far as to reach beyond the limits of the earth—to the rising moon. Now, an eclipse of the moon is nothing more than this; it is the shadow of our earth which, when the sun and moon are exactly in opposition to each other, is thrown upon the moon in the same way as we might fancy our own shadow to have been. An eclipse of the sun is not the effect of a shadow, for here we have the actual body of the moon intervening and blotting the sun from our view.

It may be asked, Why eclipses are not of more frequent occurrence, the sun and moon being so often in opposition? But it will easily be understood, that it requires them to be in exact opposition; and this exact opposition, owing to some peculiarities of their movements, occurs only at particular times.

The sun has now sunk below the horizon, and were it not for the effects of the refractive and reflective powers of the atmosphere, we should be left in perfect darkness; but though invisible to us, he enlightens the upper regions of the air, from whence a portion of his light is, through the medium of these two agencies, still permitted to reach us, growing fainter and fainter as he descends farther below the horizon, till the last gleams of twilight fade into darkness.

The darkness, which now surrounds us, will render more visible the flashes of summer lightning which, from time to time, are to be seen on the horizon, though unaccompanied by any sound of thunder; this species of lightning is generally harmless; the absence of thunder is occasioned by its being diffused over large and unconfined surfaces, and not collected in dense masses, as it is when the heavy cumulated clouds, rising one above another, proclaim the approaching storm. It is then we behold the distant flash, followed long after by a low rumble; presently the lightning appears more vivid, the thunder is louder, and follows closer upon it, till, in a short period, when the storm is immediately over us, the flash and the thunder appear almost simultaneously.

We know that thunder is merely the sound caused by the concussion between the electric clouds, as the lightning passes from one to the other, and therefore always happens at the same time with the flash, as the report of a gun takes place at the moment of firing. The reason of our hearing the thunder so long after the lightning, is on account of its distance from us, for sound travels only at the rate of about 1140 feet in a second of time, or a mile in nearly five seconds, whereas light is almost instantaneous in its passage,—indeed so quick that its motion is not perceptible in any earthly distance, a few minutes

being sufficient to transmit it from our earth to the sun, which is so many millions of miles off. We may, therefore, calculate the distance of the lightning by merely ascertaining the time between the flash and the thunder; if a minute elapses, we may presume the cloud is about thirteen miles off, if half a minute, six miles and a half; if five seconds, one mile; and so on according to the time.

That a thunder-storm is accompanied with danger no one will deny, and it is therefore proper to avoid needless exposure to it. The making ourselves a prominent object for the electric fluid to select in its passage to the earth, and of course the immediate proximity of any high object, such as a tree or chimney, is not desirable, but in avoiding Scylla, we must be careful not to fall into Charybdis—a man on an open heath is perhaps in as much danger as if surrounded by trees, because on the heath his height renders him a prominent object, whereas, amongst trees, the lightning will more probably take to a tree as its line of passage to the earth; but at the same time there is the danger of its finding an obstruction in its course, in which case the man would be in considerable peril: or if we were near a tall tree or chimney, we should move a few yards from them, as being decidedly conspicuous objects. Perhaps the safest place to all human probability is

in bed, more particularly with a hair mattrass beneath us, for hair and feathers are non-conducting substances, and as such are not likely to be selected by the electric fluid. But we should not recommend a too nice attention to every minute particular. It is frequently painful to witness the folly displayed by some persons on such occasions; they seem as though they forgot that their life is ever in the hands of Providence, and that He can as well strike the blow in the calm as in the storm.

Whilst on the subject of lightning, it will not be irrelevant to take a glimpse at the electric telegraph, now beginning to perform so important an office as a medium for the conveyance of ideas, quick as thought; for the passage of the electric fluid is instantaneous, although carried along a wire of many miles in length. The method of effecting the communication is by carrying a number of separate wires along a line of posts erected for the purpose: these wires are disconnected from the posts by passing through glass tubes fixed on them; the communication, therefore, from one end of the wire to the other, is rendered perfect. A galvanic battery being now attached to the wires at one end, separate shocks can be passed along any particular wire, which shocks are rendered visible by the movement of needles attached at the other extremity; by this means it is easy to conceive that a sentence can be communi-

cated with facility, as the wires denote the separate letters. It is not, however, necessary to have twenty-four wires, one for each letter, as many letters can be omitted without inconvenience, and each wire is capable of conveying two or more signals by the different movement communicated to the needles. A bell is also rung by the same contrivance, to draw the attention of the person attending upon the telegraph.

This certainly appears one of the most extraordinary inventions of modern times, and one that but a very few years ago would have been treated as more chimerical than any of the inventions of the creative imagination of the Arabians in their wonderful tales. It is now in contemplation to carry this telegraph across to the Continent, by sinking a wire, cased in some non-conducting substance, such as Indian-rubber, to the bottom of the sea, between Dover and Calais: the execution appears very possible, though there will, doubtless, be great difficulty in protecting it from damage from the anchors of ships, and many other causes.

A very clever application of this same electric fluid has lately been made by Mr. Bain, a gentleman of Edinburgh, who has succeeded in establishing a clock, the pendulum of which, instead of being kept in motion by the force of a spring or weight, is actuated by a current of electric fluid, produced,

not by a galvanic battery, but merely by burying a block of zinc in one place, and connecting it by a wire with a block of copper in another place. It appears that when thus situated a constant current of electricity is kept up between the two, which will last as long as the metal remains, producing by this means a clock which requires no winding up, and may be considered as almost perpetual motion. He has also applied the same method to the purposes of an electric telegraph, and as he causes the wires to be placed underground, in a bed of asphalte, a non-conducting substance, instead of suspending them on poles, it is likely to be much more economical, besides removing the very unsightly object of a long line of continuous wires; which coming as they do across the middle of the line of sight from the windows of the railroad carriages, become, on a long continuance, very unpleasant,—more especially as the wires droop slightly between each post: this, from the rapidity with which the train moves, gives a constantly waving motion to their appearance, and to some persons causes a very disagreeable sensation.

How extraordinary is the fact that these wires are, perhaps, at the moment we are regarding them, passing secret communications from one place to another! How little, perhaps, did the murderer Tawell think, as, with the torture of a guilty conscience, he was whirled past those silent tell-tales,

on leaving the scene of his horrid crime, that they were at that moment conveying the fearful intelligence, describing the deed and himself as connected with it, so that when he left the train, thinking that his secret was known only to himself and his God, that even then the eyes of the police were upon him, and that his every movement was watched, to be brought forward against him when he should presently appear before the offended justice of his country!

We will now return to the subject of sound, which we found so convenient in calculating the distance of the thunder-cloud, and we can apply the same means to ascertain the distance of many other objects; such as a ship firing a gun at sea, or a man using an axe, by observing when he strikes the blow, and allowing 1140 feet for each second of time which elapses, we shall arrive at a very tolerable idea of the distance.

As a watch is not always at hand, a very good substitute is formed by putting the fingers on the wrist, and counting the beats of the pulse; by allowing 1000 feet for each pulsation, we shall arrive at nearly the same result.

Sound is much more distinctly heard over water than over land, water being a better medium for conducting it, and its surface offering fewer obstacles to its progress. On a still evening, the sound

of human voices in common conversation can be heard at nearly half a mile distance, over a calm river, whilst it would not be audible any where near the same distance over land. Some solid substances, such as a long piece of timber, or even a brick wall, will be found excellent conductors of sound; a very slight whisper at one end will be very distinctly heard at the other, and with much greater rapidity than through the air: so much so, that the sound may be heard along the wall, and afterwards through the air, thus producing two sounds, from the difference of the speed with which it has travelled.

If a common poker is hung by two strings, and the ends of the strings are suspended over the balls of the thumbs and pressed against the ears, the poker, if struck by another iron, will produce a sound, to the person holding the strings to his ears, as loud as a heavy church bell, whilst to another person equally near, but without this conductor for the sound to pass along, it will be merely a slight vibration; in the same manner a poker applied to the lid of a kettle whilst beginning to boil, and the upper end touching the ear, will render the boiling sound visible long before it can be otherwise detected. The whispering gallery at St. Paul's is a proof of the extraordinary effect of the power of conducting and reflecting sound possessed in some situations; and history furnishes us with many wonderful accounts

of the effects produced by a scientific management of these powers, of which none are more curious than the tales of Dionysius' "Ear," as it was termed, although in this case science was sadly perverted to the vilest of purposes.

# CHAPTER VIII.

## NAVIGATION — LATITUDE.

> **"Give me the way of wandering stars to know,**
> **The depths of heav'n above, and earth below;**
> **Teach me the various labours of the moon,**
> **And whence proceed the eclipses of the sun."—DRYDEN.**

AMONGST the various sciences which tend to the happiness of man, by increasing his comforts and adding to his luxuries, that of Navigation stands pre-eminent; and we have devoted a chapter to its consideration, as placing before our view the benefits resulting from a habit of reflection. Astronomy, on which the science of navigation is founded, is of very remote origin, and has ever been the favourite study of those whose occupations have led them to spend much of their time in the open air, more especially in the night season; and consequently we find the shepherds who watched their flocks in the early ages on the plains and mountains of Asia, to have made considerable acquirements in the knowledge of the movements of the heavenly bodies, though mixed

with much error. They observed the course of the planets, and gave names to the various constellations of stars, and thus laid the foundation for an acquaintance with those sublime wonders, which cannot be contemplated without enlarging and elevating the mind beyond the limits of our present state of existence; hence we find the pastoral life to have abounded with examples of piety and simplicity,—for what can more conduce to a pure and simple mind, than the pervading feeling of the immediate presence of the Deity, which the constant study of His sublimest works, far from the busy haunts of men, and in the stillness of night, must produce?

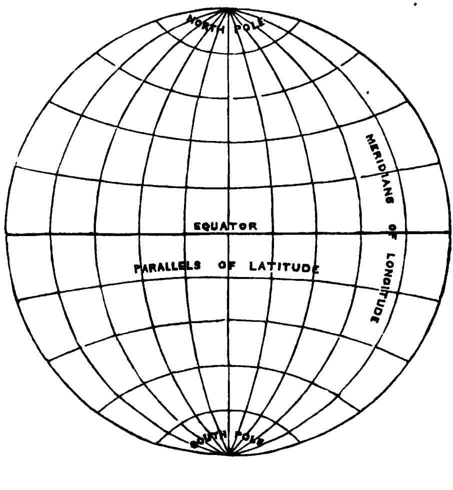
To this study, then, the art of navigation owes its origin; for, from a knowledge of the motions and situations of the planetary system, the mariner is enabled, when his bark is heaving on the billows of the interminable waste of waters, far from land or any object to mark his situation, to tell, with unerring certainty, the exact place on that trackless, boundless plain, where he is situated—so that he can mark on his map the spot where he is, and thence learn, from the sad experience of former navigators, to avoid those hidden rocks and shoals on which they have made shipwreck, and to shape his course for his destined haven. Astronomy is, in short, to the mariner what the direction-post is to the weary traveller on the desert heath.

On a cursory glance, it appears wonderful that observations made on the heavenly bodies, which are situated so many millions of miles distant from us, should enable us to ascertain, to a very great nicety, our situation on the earth; but such is nevertheless the case; and we hope, without entering into the minutiæ of the subject, to give our readers an insight into the theory of the science.

The earth has been surrounded by geographers by a number of ideal lines or rings, encircling it at regular distances, from the equator to the poles; these are called parallels of latitude, and are numbered from 0 to 90, the distance between the equator to the pole being divided into 90 parts or degrees: the ring next to the equator is called the first degree of latitude; the next, the second degree; and so on till we arrive at the pole, or 90th degree of latitude. These divisions are again crossed by a like number of lines running from pole to pole, called lines of longitude; the one which, in its passage from the north to the south pole, passes through Greenwich Observatory is termed the meridian of Greenwich, and in England each separate line is counted as so many degrees to the east or west of Greenwich. The globe is thus divided into a number of small compartments. Now if we can first determine on what parallel of latitude we are placed, that is, our position as far as regards north and south; and if we

can then also determine on what line of longitude we are situated, that is, our situation as regards east and west; the intersection of these two lines will be the position required.

The diagram, which represents half a globe, surrounded by these ideal circles, in which the horizontal ones represent parallels of latitude, and the perpendicular ones lines of longitude, will at once render this obvious.

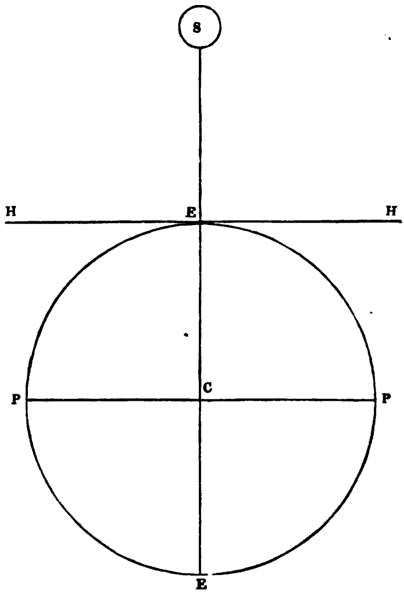



We will first turn our attention to latitude. To assist him to determine this, the mariner is provided with an instrument called a sextant, or quadrant, which enables him to determine accurately the

angle subtended between two bodies, or their altitude above the horizon: thus, if he wished to ascertain the angle of the sun above the horizon, and were to point one leg of a common two-foot rule to the sun, and the other to the horizon, the angle at the joint of the rule would be the angle that the sun was above the horizon. The sextant is only an instrument to obtain this angular admeasurement to a greater nicety. Now to determine our latitude by an observation of the sun, we will suppose the time to be noon, on the 21st of March, the day on which the sun crosses, or is vertical to, the equator; consequently, if at noon on that day, the hour when the sun has attained his greatest altitude, he was observed to be 90 degrees above the horizon, that is, vertical to us, we should know that we were on the equator. But supposing instead of the angle being 90 degrees, we should find it only 40, it would be evident that we were not on the equator, but as many degrees from it as 40 is distant from 90; our latitude would then be 50 degrees. Or were we situated at the pole on the same day, the sun would appear just on the horizon, and have no altitude, shewing a difference of 90 degrees between that and the angle at the equator; we should, therefore, know we were in 90 degrees of latitude, or at the pole. This will be rendered more clear by having recourse to a diagram.

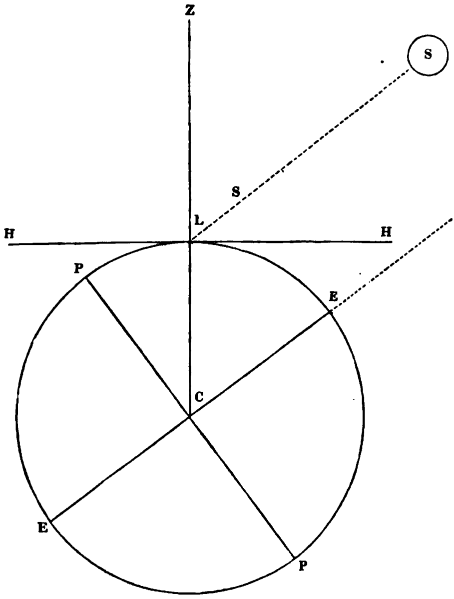
Let us suppose the observer to be situated on the

equator, and the time to be noon on the 21st of March, on which day the sun crosses the equator. The circle represents the earth, the line E E the




equator, P P the poles, the line H H the observer's horizon, S the sun, perpendicular to him. Now as on that day the sun is vertical or perpendicular to the equator, the observer finding the angle between the sun and the horizon to be 90 degrees or

vertical, is aware that *he* must be on the equator, which decides his latitude. But supposing the observer to be placed at London instead of on the equator, as in the former diagram. Here we have




the circle to represent the earth; E E the equator; P P the poles; L London, the place where the observer is situated; H H his horizon; Z the zenith, or point vertical to him; S S the direction in which

the observer sees the sun, parallel with E E; for though the sun is really in a line with the equator E E, his great distance from the earth is such that for our purpose the two lines may be considered as parallel. It has been stated that latitude is reckoned from the equator to the pole; consequently, the angle made by a line drawn from the equator to the centre of the earth, meeting another drawn from the place whose latitude is required, represents the latitude; thus the angle C represents the latitude of London, and will be found to measure 52 degrees. But as we cannot dive to the centre of the earth to measure this angle, we have recourse to an external object to effect the same purpose. It is clear that the angle at L is equal to the angle C, because they are caused by parallel lines crossing the same line — S S and E E being parallel. If the observer could therefore take the angle from S, the sun, to Z, the zenith, it would represent the required angle C; but this he cannot do, because there is no point in the heavens above him to mark his zenith. But from the zenith to the horizon he knows to be a right angle or 90 degrees; therefore, if he takes the angle from the sun to the horizon, and subtracts it from 90, he has the required angle L, which, again, being equal to the angle C, denotes his latitude.

Having obtained this, half of the difficulty is solved;

indeed, for many years navigators did not get much beyond this point, the cross-line or line of longitude being then attended with so much difficulty in the solution as to be almost useless to them. The way they shaped their course in those days was in the following manner. They would first sail in a direction southward or northward till they had arrived at the parallel of latitude on which the port they were in quest of was situated; they would then shift their course to due east or west, keeping always the same latitude, and thus continue till they discovered the land a-head. This was a very tedious and dangerous process, because they could not tell how far they might have to run, and were consequently entirely dependent upon a good look-out, lest they should come upon it unawares. And during the night or in foggy weather they were obliged to reduce their sail, even though the wind might be favourable, and to make as little progress as possible—something like children playing at blindman's-buff, who are anxious to get to the object, but at the same time proceed very cautiously, not knowing where the tables and chairs, which may represent the rocks and headlands of an approaching coast, are to be found. If the place to be arrived at were only a small island, there was, as not unfrequently happened, the chance of passing on one side of it in thick weather, and the poor voyager might continue days in error, sailing on

in search of that from which he was daily becoming more and more distant. And supposing all these difficulties to have been avoided, there was still the increase of distance requisite on sailing along the two sides of a right-angled triangle, instead of taking the diagonal, like a person walking round the two sides of a square to arrive at any particular house, instead of crossing it obliquely.

We will, however, defer the consideration of this second difficulty to the next chapter, premising only that, although the practical attainment of longitude has been beset with many difficulties, and is still much more complicated than latitude, yet its theory is very simple, and, we think, will prove a very attractive subject.

# CHAPTER IX.

## NAVIGATION CONTINUED—LONGITUDE.

> "Rude as their ships was navigation then,
> No useful compass or meridian known;
> Coasting, they kept the land within their ken,
> And knew no north but when the pole-star shone."
>
> DRYDEN.

LONGITUDE, as we stated in introducing the subject of navigation in the last chapter, is denoted by ideal lines intersecting the earth from pole to pole, resembling the sections of an orange when cut from the crown to the stalk. In England, longitude is reckoned either as east or west of Greenwich; that is, the first of these ideal lines, from the north to the south pole, passes through the Royal Observatory at Greenwich. Any place to the eastward of it is described as so much east longitude, or if to the west, as west longitude; whereas, if it is directly north or south of Greenwich, it would be called on the meridian of Greenwich. Longitude consists, therefore,

in our different situations as regards east and west; and this difference is rendered perceptible to us by the different hours at which the various meridians come under the sun.

The earth revolving on its axis or poles brings the same place under the sun every twenty-four hours, causing by its revolutions our days and nights; now as twenty-four hours give the whole circumference of the globe, or 360 degrees, every hour will give one twenty-fourth part of it, or 15 degrees; and so on for every division of time.

When any meridian comes under the sun, it denotes noon, or twelve o'clock; consequently, if we possess a watch regulated to Greenwich time, and find that when the sun indicates noon, or twelve o'clock, in the place where we are, that the watch shews one o'clock, it is evident that we are an hour to the westward of Greenwich, the sun having passed Greenwich meridian one hour before he arrived at ours: we are therefore 15 degrees, or one twenty-fourth part of the way westward, round the globe.

To illustrate this, we will refer to the little diagram in the frontispiece. The movable circle represents the northern hemisphere of the globe, the circumference forming the equator; the circles, parallels of latitude; the radiating lines, meridians of longitude; the dark line below, the

twelve o'clock line, being the direction in which the sun is supposed to shine: consequently, when any part of the movable circle is brought opposite to this line, it is noon, or twelve o'clock, to that place. The figures round the outside denote Greenwich time, and may be considered as a clock regulated to Greenwich time, of which the line marked "Meridian of Greenwich" on the movable circle may be considered as the hour-hand or index, because whatever figure it points to represents Greenwich time, when the world is in the position with regard to the sun represented by the diagram.

Let us now turn the circle till we bring New York under the sun; it is then noon, or twelve o'clock, at New York. But what is it by Greenwich time? By looking at the Greenwich clock on the outside circle, we find the hand, or line marked "Meridian of Greenwich," pointing to five, indicating that it is five o'clock at Greenwich; consequently, there are five hours' difference between that time and the time at New York, or five hours' difference of longitude. Now, as in each hour the earth revolves 15 degrees, five hours will give 75 degrees, or rather more than one-fifth part round the world. Thus the sun may be considered as the hand, which, pointing to the earth as it revolves, marks out the different degrees of longitude, whilst the clock is the interpreter which indicates what those degrees

are. At noon, by the dial, it tells us the sun points to Greenwich; and every place on that meridian, at one o'clock, to a meridian removed 15 degrees to the west of it; at five, to New York; at midnight, to our antipodes; at six in the morning, to India; and so on till noon again. A navigator, therefore, if furnished with a chronometer, or watch, on which he can depend, and having regulated it to Greenwich time before leaving the Thames, will have little difficulty, at any time during his voyage, in determining his longitude: but as instruments of this description are ever liable to error and casualty, he turns for a substitute to the unerring hand of Nature, and makes the starry vault of heaven his clock.

Had there been some phenomenon which took place at stated intervals, such as the extinction and re-appearance of some particular star, or were the eclipses of the sun and moon of daily occurrence, knowing, by calculation, the moment they would happen by Greenwich time, they would answer the purpose of the clock in the diagram; but such not being the case, and the eclipses of the satellites or moons of Jupiter, though of frequent occurrence, being too minute for common observation, astronomers have sought for other means, and the moon, which, from her near proximity to us, alters her apparent position very rapidly amongst the heavenly

bodies, has supplied an admirable substitute. For this purpose, the angular distance that the moon will be from the sun, or from some particular star, every third hour of the day and night, is calculated with great exactness, and published in the "Nautical Almanac." The mariner has only, therefore, to measure the distance between these two bodies, and, by looking for the hour when a corresponding distance would take place by Greenwich time, he can determine his difference of longitude from that meridian by the difference which exists between the time of his observation and the computed time already mentioned.

A more beautiful application of the phenomena of the heavens to the uses of man it would be difficult to discover, or one exhibiting greater skill, accuracy, and profound depth of calculation. I have here merely given the principle on which this calculation for longitude is based, leaving out the various practical difficulties which would only tend to render the subject too complicated for admission in this elementary work.

The rapidity of railroad travelling brings these variations of time, occasioned by difference of longitude, very prominently into view on those lines running in an east and west direction. A traveller on the Great Western railway would find that his watch, which was correct on his leaving London,

would, on his arrival at Exeter, be about fifteen minutes in advance of Exeter time, he having traversed nearly four degrees of longitude; and were the clocks on the line regulated by local time, the difference between them and his watch would mark his progress to the westward, every four minutes of difference shewing a degree of longitude. Railway clocks are, however, now generally regulated by Greenwich time, as the variations between the different stations would otherwise cause much difficulty and confusion. To remedy the inconvenience resulting from the railway clocks differing from the local time, some have lately been constructed with two hands, the one shewing Greenwich and the other local time; the difference between the two hands being the difference of longitude in time, or the time it would take for the earth to turn that portion of a revolution comprised between these two places.

Were two travellers to set out from London on a voyage round the world, the one traversing the globe from west to east, and the other from east to west, the one who travelled to the east would gain a day by the time he had circumnavigated the globe, he having by his own movement round the earth made one revolution more than the earth itself, consequently producing one more rising and setting of the sun than had he remained stationary; whereas

the traveller who went towards the west would lose a day, he having by his own movement, in a contrary direction, made one revolution less than had he remained at home. The days of the former would each have been shortened, by as much as he advanced in longitude, in time every day; and the days of the latter would be lengthened in a similar manner. When they had both completed their journey, and met again in London, the one would call it Monday, the other would affirm it could only be Saturday; at the same time the chiming of the bells, and the quiet diffused over the busy world on that happy day of rest, would clearly indicate that both were in error, and that it was Sunday: the assistance of the philosopher would be required to blend all these seeming inconsistencies, and to account for them on scientific principles.

We here behold what labour and calculation has been required to enable the mariner to direct his course from shore to shore; and yet we find the feathered wanderers of the sky winging their way from one continent to another without chart or compass to direct their track, and yet with a certainty and precision that seems to mock the more laboured efforts of the mind of man. To account for this extraordinary faculty implanted in them by their beneficent Creator is beyond our power. We can only behold in it a further proof that to every creature

has God awarded instincts according to their several wants and necessities; and it should teach us to rely, with still firmer confidence, in Him who hath so carefully provided for the wants of all His creatures.

# CHAPTER X.

## THE SEA-SHORE.

> "And thou, vast Ocean, on whose awful face
> Time's iron feet can print no ruin-trace;
> By breezes lull'd, or by the storm-blasts driven,
> Thy majesty uplifts the mind to heaven."—MONTGOMERY.

THE last two chapters having directed our attention to the sea and nautical affairs, we will now extend our inquiries along the coast, and examine some of the wonders which old Ocean is constantly performing.

The beach on which we walk, strewed with pebbles round and smooth almost as marbles, tell of the many ages that must have elapsed since those stones were once a solid rock. One may here trace the first opening crack or fissure between the severing mass and the parent stone, how from time to time the constant but imperceptible flow of the waters widened the opening, till at last the fragment became entirely disconnected. The same constant influence,

we may suppose, again reduced it to a smaller piece, till by degrees the ebb and flow of every separate wave rolled it over and over amongst myriads of similar shapeless masses, till at last the sharper angles were removed, and it became a smooth and polished stone, reminding us of the influence of society upon man rubbing off all the sharper angles and asperities of his nature, and transforming the rough schoolboy into the polished man of the world; and it is well if in the polishing some of the more valuable qualities have not been washed away also.

Small as these rolling pebbles are, they perhaps offer a greater obstacle to the encroachments of the sea than the more solid rock skirting the distant shore, and whose bold and rugged surface tells of the constant action to which we have just alluded; nay, here and there we find a huge dissevered piece, round which the waters have forced a passage, transforming it into an island, and then gradually lessening in circumference, till the island disappears. We may well imagine that our own happy isle was once a portion of the Continent; for, on looking at a map of England, we see how the Thames on one side, and the Severn on the other, cut deep into our coasts; and two similar rivers a little farther south may have formed the commencement of the English Channel, where, a passage once gained, the waves of the Northern Ocean would soon

increase its width, till it became as it now appears; and when we see the changes which even a few years produce on some coasts, we can easily estimate the effects of the continuous wash of ages.

It is very curious to remark how the tide affects a bold cliffy shore. It first attacks the base of the cliffs, every returning tide wearing a little further into its recesses, till at last the overhanging top preponderates and falls, forming a vast ruin below, which for a time protects the cliff from further injury; till again removed by the tide, the same process is repeated. Thus we find that on all the softer cliff-bound coasts the ocean is rapidly gaining, much more so than on the flat sandy or pebbly beach. The one, though offering apparently so much stronger a barrier than the other, is easily sapped at its foundation, whilst the sea rolls harmless over the other; indeed, these latter are often carried by the waves themselves and deposited on the shore, forming for itself the very defence which sets bounds to its domain.

Many of our rivers and harbours are beset by barriers of this description, which it has taken immense labour and expense to remove. Some, indeed, have baffled all the skill of the engineer, who, when he has perhaps flattered himself that by forming a backwater he has vanquished the obstruction, a strong wind from some particular point has again replaced the bank, and taught him that to contend with Nature

is no easy task, and that the works of years may in a moment be rendered of no use or effect.

Not a rivulet pours its scanty stream into the ocean which is not engaged in carrying on the process of change, bringing with it some earthy portion or sediment as its tribute to the sea. Vast tracts of land have thus been formed at the mouths of large rivers, such as the Nile, or Mississippi, where hundreds of miles of low swampy country have been formed by the deposits from their turbid waters.

The land of Egypt owes all its extraordinary fertility to the deposit left from the overflowings of the Nile, which brings the riches of the mountain soils down into the plains, forming, as at the mouth of the Mississippi, fertile land where once the ocean rolled. The port of Alexandria on the coast of Egypt grows every day more shallow; and Damietta, the walls of which were washed by the sea in the thirteenth century, is now considerably inland. Again, the coast of Holland has been subject to remarkable vicissitudes from the effect of the sea. In the earliest history of this country it is described as composed of large marshes, alternately inundated by the sea and rivers. The first threw up sand upon the shore, whilst the rivers deposited mud, and thus elevated spots were formed, round which industry and perseverance raised embankments, thought to be capable of withstanding the utmost fury of the waves. The

country, however, still remained intersected by lakes and rivers, which silently undermined these new-formed lands, and the sea in high tides rushing up the rivers produced the most fearful inundations. Prior to 1250 the Zuyder Zee was a lake of middling size, which communicated with the British Sea by the river Vlee; in that year an irruption of the sea gave it its present form and extent. In 1300 the Gulf of the Dollart was a rich plain, and in 1421 a united inundation of the sea and rivers formed the Bresbock, by submerging no fewer than seventy-two villages, and a population of one hundred thousand souls.

These, indeed, are some of the larger and more astonishing works of Nature; but great things have ever their origin in small ones. The brook is the parent of the river, the river again may in time become an arm of the sea. The researches of the geologist furnish us with immense food for speculation, and with some few facts which lay near the surface of the earth to enlighten us upon its past history; but his researches, after all, are but superficial, and reveal to us merely some dark hieroglyphical glimpses of past ages.

The waters of the ocean yield to very slight impulsions, and are constantly agitated by three different movements—the undulatory, or waves, the tides, and currents.

Waves are produced by the motion of the wind

over the surface of the sea; and when this amounts to no more than a gentle breeze, the undulatory movement passes slowly onwards and subsides again; but when a storm arises, the ocean is furrowed by tremendous waves, or mountainous ridges of water, each of which rolls on with furious rapidity until its summit arrives at an overcharging elevation, from which it necessarily precipitates itself by the force of gravity; and by the acceleration it has acquired in its descent, impels forward the mass of water immediately before it, which, in its turn, rises, forms a wave, and again repeats the same operation; and thus a continued succession of waves are generated. The swell of the sea caused by a gentle wind will be sufficient to produce a considerable surf, when it arrives in shallow water, because the lower part of the wave is checked by first reaching the ground, and the upper portion of it continuing its progress, rushes over the lower, dashing itself upon the beach in a torrent of curling foam. Dr. Wollaston on one occasion ascertained the velocity of the waves to be at the rate of sixty miles an hour.

The next source of movement, the tides, we have already explained whilst examining the subject of attraction. We, therefore, come to the third, viz. currents, which proceed from some particular conformation in the coast, or from the more general effects of climate and other causes. A remarkable

instance of this exists in the Straits of Gibraltar, where the current always sets one way from the Atlantic Ocean into the Mediterranean Sea, the evaporation from the surface of the sea in so hot a climate being greater than the contributions it receives from the rivers that fall into it, and the water which descends from the clouds, a constant flow from the Atlantic is, therefore, necessary to supply the deficiency.

Whilst on the shore our attention will be drawn to the sea-gulls which we behold, from time to time, skimming over the sea and plunging their beaks into the wave to strike their finny prey. That birds are considerably heavier than the element in which they fly is obvious; what, then, can be the reason that they are enabled to support themselves in so light a medium? The balloon and the soap-bubble, we have before explained, rise in the air because they are filled with an air still lighter than themselves, which renders them specifically lighter than the atmosphere; but this is not the case with birds, for we see that the moment the sportsman levels his piece at the poor victim and it receives his shot, it falls heavily to the ground, shewing that its floating capacity depended on a different principle.

The flight of birds appears more to resemble the flying of a kite, which we know does not depend on

its specific gravity, because the paper and wood of which it is formed are much heavier than air; but the theory of its remaining suspended depends on the pressure of the wind on its under side acting against the resistance of the string by which it is held, and the oblique position in which it is balanced causes it to ascend, and as it were to float in the air. On the same principle, birds can only remain suspended whilst they continue moving through the air; and the motion of their wings impelling them forward has an effect similar to the string of the kite, for it is the same thing whether we pass through the air, or whether the air passes by us. On a calm day, the boy cannot get his kite to ascend, unless he continue running with it, thus causing it to pass through the air; but on a windy day the kite will rise though he remain stationary. Whilst the bird, therefore, continues in motion, it floats in the air, by the resistance of that fluid against its breast and the under surfaces of its wings. We may often watch a large bird, when descending from a height, with wings outstretched, soaring along without any apparent exertion. The momentum he has acquired, assisted by the descending nature of his flight, enables him to pass over a great distance on this inclined plane before he reaches the ground. If, instead of alighting he still continue his flight, it will be observed, that as soon as he changes to a

horizontal direction, he is obliged to make use of his wings to propel himself along. The tail of the bird acts the same part as the rudder to a ship, for by it he directs his course, and elevates or depresses his flight at pleasure.

From observing the feathered tribe, we will now turn our attention to the dwellers in the deep; and here we find that fishes float according to their specific gravity, and are enabled to alter this gravity at pleasure, by means of an air-vessel situated in their bodies, which is surrounded by a strong muscular fibre. When the fish wishes to descend, he compresses this air-vessel by means of the muscle. This reduces the bulk of the fish, and accordingly it sinks. When wishing to ascend again, the fish relaxes the fibre, the compressed air then immediately expands, and the fish becomes specifically lighter, and rises to the surface. When fishing for cod where the water is very deep, it is no uncommon circumstance for the fish to be found with the air-bladder burst on arriving at the surface of the water. This arises from the rapidity with which the fish has been hauled up, having removed the pressure from the outside of the air-vessel before the membrane has had time to dilate and expand itself; and, consequently, the sudden expansion of the air within, when the outer pressure is removed, causes the vessel to burst, and destroys the fish. Surely

nothing can be conceived more beautifully arranged than this means which the fish possesses of adapting itself to the different densities of the water in which it swims; but every work of Nature is alike replete with the same perfection, though we discern but a very small portion of its beauties.

From our observations on birds and fish we are naturally led to the ship, which we see boldly combating the waves, and holding on her course in opposition to the wind, though propelled by it; which appears rather mysterious till we become acquainted with the cause of her movement.

The ship partakes of the bird and the fish, her sails representing the former, whilst her hull bears a similitude to the latter, and we must remember that she belongs to two elements, air and water; and it is by this means that she is enabled to direct her course, by causing one element to resist the other; and thus by the opposition of two forces to oblige the vessel to take a direction between them. The balloon, which floats in one element alone, has no power by which to direct its course, because there is no second element to contend with it, but where the wind blows it, it must go. Not so, however, with the ship. To explain this we will suppose the wind to be blowing from the north, and the port to which the vessel is bound to be in that direction, so that she has to proceed exactly in opposition to the wind,

impelled by her sails alone; for we are now talking only of sailing vessels, and have nothing to do with any mechanical means of propelling the ship. In this situation it is obvious that if the vessel's sails were hoisted, and her head brought facing the wind, that its action would be to drive her directly back;

but if instead of this her head be brought in a direction tending northwards, and her sails be set diagonally across the vessel, then the action of the wind will be partly to urge her forward, and partly

to press her sideways in the water; but here she meets with resistance, and to avoid it the hull of the vessel will glide through the water in the direction of her bows, that being the line of least resistance. By this means the ship will take a direction as shewn by the accompanying sketch, in which the vessel is trying to make progress in opposition to the wind, which is supposed to be blowing from the upper part of the sketch in the direction of the perpendicular shading. The lines across the vessel shew the direction of her sails, with the wind blowing down upon them; which will explain the description, how the wind pressing on the sail, and the resistance of the water on the opposite side, must cause the vessel to move forwards. When she has gained the point marked by the dotted track, the vessel will be put about, or tack; that is, the head of the vessel will be turned in the direction shewn by the second ship, her sails being brought round so as to impel her forward in that line; and thus by repeated tacks the vessel will at last reach the port, although the wind has been against her. The writer has often heard those unacquainted with nautical affairs remark upon this tedious process of tacking to windward, which to them seemed a most roundabout way of proceeding, and more especially so when they have been suffering from the effects of a rough sea, and at every fresh tack have felt all the agonies of hope deferred.

# CHAPTER XI.

## CONCLUSION.

> **" Knowledge, when wisdom is too weak to guide her,**
> **Is like a headstrong horse, that throws the rider."—QUARLES.**

THE acquirement of knowledge consists in the registry of facts in the mind, ready to be applied as they may be required, and it is this faculty of applying facts thus garnered in the brain which constitutes wisdom. The mere possession of knowledge may be only the work of a good memory, and serve but little purpose, without wisdom to apply it to good account; it may be compared to a huge folio volume without an index, full of valuable information, but useless to its possessor at the moment it is required from a want of arrangement, and the means of arriving at its contents.

Having in the preceding chapters, as far as our proposed limits would permit, taken a glimpse into some of the most striking and prominent features that have attracted our notice in our daily career, it

now remains only to add a few reflections, suggested by the occurrences we have been occupied in observing, and to assist our young reader in the art, so to arrange his inquiries and mode of thinking that he may the more readily be enabled to explain for himself the cause of any fresh fact which excites and interests his inquiring mind. In the commencement of this little book we were introduced to the subject of vapour, by observing its condensation on the window; and as we proceeded farther we found the subject enlarging itself, and gradually expanding, till it carried us to the formation of clouds, their descent in rain, and the various phenomena of the atmosphere. We might have pursued the subject to an indefinite extent; for it may be considered as a distinguishing characteristic of the study of Nature's laws, that the more we accumulate knowledge of them the more vast does the field for our contemplation become, rendering us sensible of our own ignorance; the want of information being only felt by those whose active minds have led them to thought and inquiry. The word ignorant is often applied to convey reproach, but it should be remembered that we are all ignorant till we are taught by others, or, what is far better, till we have acquired knowledge for ourselves: the term is reproachful only when it speaks of opportunities of information neglected, and of talents unimproved.

In conducting our inquiries into any particular effect, it is first requisite clearly to define what are the peculiarities belonging to it, and what it is that we purpose to ourselves to explain. We should then turn our attention to the various means by which such an effect could be produced, and then to examine into the local or other causes which may at the time be exerting their influence upon it.

By thus arranging our inquiries upon a systematic principle, much confusion and many false deductions will be avoided, and our premises will proceed, step by step, to an elucidation of the occurrence. We should then test and establish our theory by any concurrent circumstance that may present itself; but we must not be disheartened should we find, as will often be the case, that our theory will not bear this examination, and is, therefore, fallacious: we shall have gained experience by the attempt, and our further inquiries will be based on surer grounds, till in the end success will most probably crown our endeavours. And should it not, the knowledge obtained even from our failures will fully repay us for the time and labour bestowed upon them.

But to those who pass through the world, as many do, without a wish even to increase their knowledge, or to examine into the wondrous works of Nature, satisfying themselves with the opinions of others, seeing with other men's eyes and reasoning with other

men's faculties,—to such persons I would say, Was man created only a little lower than the angels, the possessor of an immortal soul, thus to bury the talent committed to his charge? No, assuredly; for

> "We are held
> Accountable; and God, some future day,
> Will reckon with us roundly for th' abuse
> Of what He deems no mean or trivial trust."
>
> COWPER'S *Task*, book vi.

Nor need we fear that the man of an inquiring mind will ever be puffed up with vanity and self-conceit; for the more he sees and observes, the greater will his admiration of the goodness of his Creator become, and the more humble his opinion of himself, because he is always reminded that his faculties are finite, whilst the God whose works he studies is infinite.

To the observing mind an hour never passes without food for reflection. The rich, though often uncultivated soil of human intellect, will be constantly furnishing us with subjects for contemplation. The air in which we breathe, the earth on which we tread, the broad expanse of ocean, and the starry vault of heaven above us, are all replete with wonders. The vegetable kingdom alone would afford subjects for a lifetime. The flowers that draw their nourishment from the soil, the air, and the dew, are all furnished with functions suited to their different natures;

some turn their delicate heads to the cheering rays of the sun, and seem to drink deep from that fountain of light and heat, and close their petals the moment he departs from their view; whilst others hide themselves in the shade, and shun the approach of day: to each Nature has appointed its proper place, and proper powers for keeping in the station allotted to it. In the brute creation we may observe the same order. To the domestic animal she has given strength and docility; to the beast of prey, the eye capable of piercing the darkness, and agility to seize on its destined victim; to the bird of passage she has given strength of wing, and a wonderful instinct to direct its flight. Again, if we descend into the depths of ocean, fresh wonders meet our view—from the mighty whale, the monarch of the deep, down to the diminutive minnow, each as perfect as the other, though on so different a scale. Then, turning to the insect world, we see the laborious ant heaping up her store for winter consumption; the bee, building her hexagonal cells with a regularity equal to that of the nicest architect; the spider, weaving her delicate thread to catch her prey; the glow-worm, "with its modicum of light," sparkling in the dewy grass; each with its separate sphere of usefulness, each separate insect affording a fresh theme for inquiry; and, were it possible to exhaust all these, one glance at the microscope would again overwhelm

us in endless objects of research. The secrets hidden in a single drop of water, which the microscope has revealed, are almost beyond our conception, discovering to us myriads of beings filling every atom of creation, and forming a world of which we scarcely know the existence. But even all these sink into nothing when compared with the wonders of the starry firmament, where thousands and thousands of suns, each the centre of a system of worlds, peopled perhaps with beings destined for immortality, are nightly presented to our view. The extent, the magnitude, the harmony of Nature, fill us with awe and admiration, and we are lost in the contemplation of the attributes of that Being whose Almighty arm supports, controls, directs, and governs all.

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